



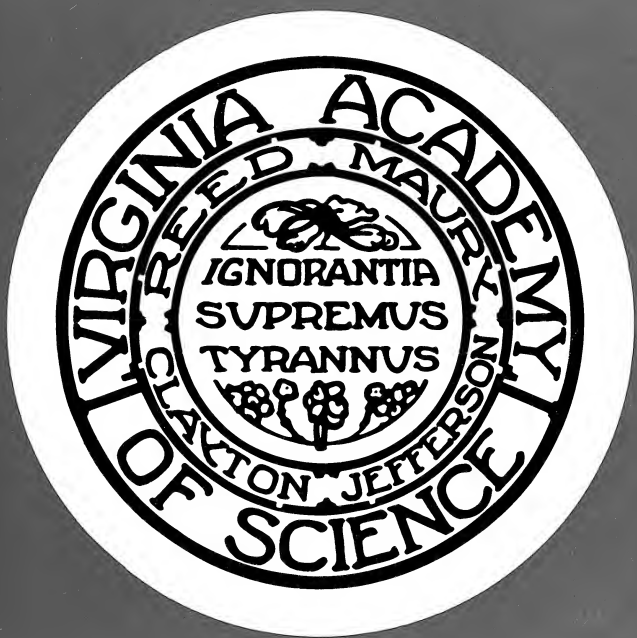




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# VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE



VOL. 26, NO. 1



SPRING 1975



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Vol. 26

No. 1

Spring 1975

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# THE VIRGINIA JOURNAL OF SCIENCE

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Official Publication of the Virginia Academy of Science

EDITOR

DAVID A. WEST

## Editor's note

There have been several inquiries as to the method by which manuscripts submitted to the Journal are reviewed. Ordinarily two outside reviewers are asked for their comments. Since May 1974, when I took over, these reviewers have been from out of state for the most part, and they have been chosen for their competence to make technical comments and to judge the manuscript from a broader perspective. Their comments, together with those of the editor, are sent to the author with notice either of rejection or of acceptance, in the latter case with or without revision. The outside reviewers contribute invaluable to the editorial process and help to ensure that the papers published in the Journal will meet properly

high standards. Even though the Journal will quite properly remain regional in its approach it need not be parochial. The papers published in the Journal will necessarily vary in their appeal, and they will include both original scientific results and matters of more general interest. In this issue both types of papers are represented. Recently the submissions have been very heavily weighted toward the biological sciences. I welcome suitable manuscripts from other areas while recognizing that there are some disciplines in which people nearly always publish in specialized journals.

Since May 1974 there have been 19 manuscripts submitted; 10 have been accepted, 7 rejected and 2 are pending.

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Published quarterly by The Virginia Academy of Science, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Second-class postage paid at Richmond, Virginia.

Manuscripts for publication (other than section abstracts) should be sent to the Editor, Dr. David A. West, Department of Biology, V.P.I. and S.U., Blacksburg, Virginia 24061. Proof, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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Back issues are available for some years at \$3.00 per issue plus postage.

J. V. Banks, J. A. Bander and George Sanzone\*  
 Department of Chemistry  
 Virginia Polytechnic Institute and State University  
 Blacksburg, Virginia 24061

Manuscript received January 10, 1975  
 Revised manuscript received February 19, 1975

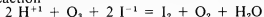
## A Practical Ozone Generator

In many laboratory syntheses, it is necessary to have a dependable, high-yield ozone generator. Although there are many such generators described in the literature, these are usually unduly expensive; moreover, their descriptions do not stress those practical experimental details upon which successful operation depends. In this note, we describe an inexpensive, yet highly dependable ozone generator which we have used routinely in the preparation of  $N_2O_5$ .

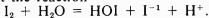
The ozone generator (See Figure 1.) consists of three concentric tubes: an 8 mm inner tube which is sealed at both ends and which is tightly wrapped with number 30 bare copper wire; a 19 mm middle tube which carries the oxygen flow and which is 80 cm long; and a 40 mm outer tube which forms a cooling-water jacket. Both inner and middle tubes *must* be made up of soft glass; if, for example, Pyrex is used, the ozone yield is virtually zero. The stoppers which come in contact with the ozone are paraffin-coated cork; rubber cannot be used because of its degradation by ozone. Both cooling-water inlet and outlet are of copper tubing so that *both* may be electrically grounded. A 12 kV, 60 Hz potential is applied to the central copper coil from a Variac-controlled transformer. (A neon-sign transformer is adequate.) The

voltage is left at maximum for highest ozone production.

The yield of the ozone generator was measured by bubbling the product through a solution 0.06 M in KI and 0.03 M in  $NH_4Cl$  (Buffer). Iodine produced in the reaction



was titrated with sodium thiosulfate in the presence of starch indicator to give a quantitative measure of the ozone concentration. The solution was buffered to prevent the reaction



Ozone yield was measured as a function of both oxygen flow rate and cooling-water temperature. Actual ozone output (as opposed to percent ozone) increased with increasing  $O_2$  flow rate. Ozone production increased significantly with decreasing temperature. The control of temperature in laboratory ozonizers seems to be generally ignored but is strongly recommended as a technique for varying ozone yield. Typical results were 0.125 ml/sec  $O_3$  (2.2% ozone) at a temperature of 23°C and an  $O_2$  flow rate of 6 ml/sec. This compares favorably with commercial ozonizers costing \$2,000.

\* To whom correspondence should be sent.

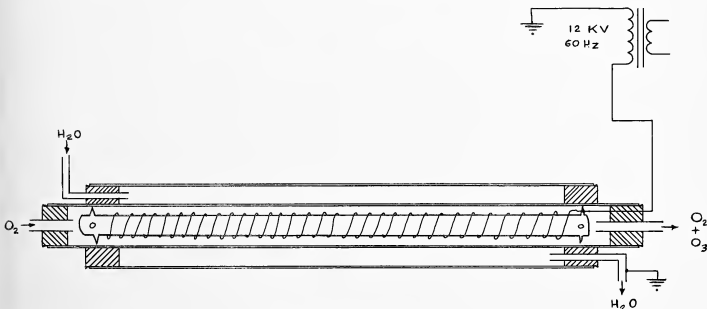


FIG. 1—The Ozone Generator.

Martha K. Roane

Department of Biology

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Manuscript received January 13, 1975

## Rhododendrons Native to Virginia

**Abstract**—A new floristic treatment of the species of *Rhododendron* native to Virginia has been prepared as a contribution toward a proposed flora of Virginia. Keys, descriptions, flowering dates, distribution and other notes have been included for the 11 taxa that occur in the various physiographic provinces of the state.

Members of the genus *Rhododendron* L. are native throughout the various physiographic provinces of Virginia from the sandy shores of the Coastal Plain through the Piedmont Plateau, the Blue Ridge Mountains, the Valley of Virginia into the ridges and valleys of the Alleghany Mountains. None of the 11 species found in the state is endemic to any area although *Rhododendron cumberlandense* Braun is limited to the Cumberland and Kanawha Plateaus in southwestern Virginia.

The data for this contribution to the proposed Virginia Flora have been compiled from field observations and collections, herbarium specimens deposited in several herbaria, and literature (Grimshaw and Bradley 1973; Hathaway and Ramsey 1973; Massey 1961; Thorne and Cooperrider 1960; Waters, Bray, and Levy 1974). Nomenclature follows Gleason and Cronquist (1963) and Wilson and Rehder (1921); see also Roane (1975). Loans of specimens for study from the herbaria of Longwood College, Lynchburg College, Morris Arboretum, National Arboretum, Old Dominion University, University of Richmond, Virginia Commonwealth University, and The College of William and Mary and use of the herbaria at the Mountain Lake Biological Station of the University of Virginia and Virginia Polytechnic Institute and State University are gratefully acknowledged.

### *Rhododendron* Linnaeus

Evergreen or deciduous shrubs with alternate, entire (rarely ciliate-serrulate), glabrous to tomentose, lepidote or strigose leaves. Buds with several to many imbricate scales. Flowers 5-merous, usually in terminal corymbs. Calyx 5-parted, various, often very small, persistent. Corolla white to yellow, pink, purple or deep red, rotate to campanulate, or funnel-form, usually irregular, with a 5-lobed limb, the median lobe adaxial; deciduous. Stamens 5-10, usually exserted from the corolla. Ovary superior, 5-locular. Fruit a septicidal 5-celled capsule, usually ovoid to oblong, 1 cm or more long.

### Key for flowering plants

- A. Mature leaves large, up to 20 cm long, thick, coriaceous, glabrous; flowers rotate to campanulate; stamens 10 ..... B
  - B. Flowers white to rose; pedicels and ovary stipitate-glandular; calyx lobes much longer than wide, mostly 2-4 mm long ..... 1. *R. maximum*
  - BB. Flowers rose-purple to lilac-purple, rarely white; pedicels and ovary hirsutulous, not glandular; calyx lobes broader than long, mostly under 1 mm long ..... 2. *R. catawbiense*
- AA. Mature leaves small, up to 10 cm long, thin, not coriaceous, trichomatous; flowers funnel-form; stamens 5 ..... C
  - C. Flowers yellow to scarlet ..... D
    - D. Flowers expanding with or shortly after the leaves; corolla over 5 cm dia; twigs strigose with fine dense pubescence between the coarse hairs ..... 3. *R. calendulaceum*
    - DD. Flowers expanding when leaves are about mature; corolla 5 cm or less in dia; twigs sparsely strigose or otherwise glabrous ..... 4. *R. cumberlandense*
  - CC. Flowers white to rose or pale purple ..... E
    - E. Flowers expanding before or with the leaves ..... F
      - F. Leaf surface glabrous; midrib finely pubescent above and strigose below ..... 5. *R. nudiflorum*
      - FF. Leaf surface pubescent; midrib densely pubescent or glandular-pubescent above and glandular or pubescent and strigose below ..... G
        - G. Stamens twice as long as corolla tube ..... H
          - H. Stipitate glands occurring along the large veins of the lobes of the corolla; corolla glabrous inside ..... 6. *R. atlanticum*
          - HH. Stipitate glands widely distributed over the surface of the corolla; corolla pilose inside ..... 7. *R. roseum*

- GG. Stamens three times as long as the corolla tube .8. *R. canescens*  
 EE. Flowers expanding after the leaves are fully developed ..... I  
     I. Branchlets pubescent; pedicels and corolla tube stipitate-glandular and minutely pubescent ..... J  
         J. Branchlets yellowish or grayish brown, hirsute or moderately strigose; corolla slightly pubescent inside above the middle ..... 9. *R. viscosum*  
         JJ. Branchlets bright red-brown, copiously strigose, finely villous; corolla tube glabrous inside ..... 10. *R. serrulatum*  
     II. Branchlets glabrous or very sparsely strigose; pedicels and corolla tube stipitate-glandular without underlying fine pubescence ..... 11. *R. arborescens*

#### Key for plants bearing fruits and leaves

- A. Mature leaves up to 20 cm long, thick, coriaceous, glabrous ..... B  
     B. Mature capsule 1-1.5 cm long, stipitate glandular; leaves acute, narrowed toward the base ..... 1. *R. maximum*  
 BB. Mature capsule 2-2.5 cm long, densely hirsute; leaves abruptly pointed at apex, rounded or subcordate at base ..... 2. *R. catawbiense*  
 AA. Mature leaves up to 10 cm long, thin, not coriaceous, trichomatous ..... C  
     C. Twigs glabrous; lower midrib sparingly strigose, buds glabrous ..... 11. *R. arborescens*  
     CC. Twigs trichomatous; lower midrib pubescent, strigose and/or stipitate-glandular; buds usually trichomatous ..... D  
         D. Capsule glandular-setose ..... E  
             E. Leaves glabrous, lower midrib somewhat strigose ..... F  
                 F. Twigs bright red-brown, usually densely strigose toward apex; bud scales pale with conspicuous dark margin; leaves serrulate-ciliate 10. *R. serrulatum*  
                 FF. Twigs yellow to gray brown, somewhat strigose or glabrescent; bud scales pale brown with no dark marginal band; leaves ciliate . 9. *R. viscosum*  
     EE. Leaves with hairs and/or glands ..... G  
         G. Winter buds grayish pubescent; young branchlets finely pubescent and sparingly strigose, grayish brown or light brown 7. *R. roseum*  
         GG. Winter buds glabrous or slightly silky-pubescent; young branchlets sparingly strigose, setosely glandular or glabrous, reddish brown ..... 6. *R. atlanticum*  
 DD. Capsule setose or strigose, eglandular ..... H  
     H. Pedicels stipitate-glandular, capsules setose ..... I  
         I. Buds glabrous; capsule setose and pubescent; leaves finely pubescent ..... 3. *R. calendulaceum*  
         II. Buds densely grayish pubescent; capsule densely grayish pubescent, sparsely setose; leaves sparingly pubescent or glabrescent above and densely pubescent or grayish tomentulose beneath ..... 8. *R. canescens*  
     HH. Pedicels strigose to strigose-pilose; capsules strigose .... J  
         J. Outer scales of yellow-brown winter buds aristate with awn as long as body of scale; capsule strigose ..... 4. *R. cumberlandense*  
         JJ. Scales of brown winter buds ovate, abruptly acuminate; capsule finely pubescent and strigose ..... 5. *R. nudiflorum*
1. *Rhododendron maximum* L. Rose Bay. Great Laurel. White Laurel. Shrub or small tree up to 10 m tall. Twigs grey-brown, scurfy. Bud scales red-brown, tomentose, ciliate. Leaves thick, coriaceous, evergreen, oblong-obovate, 10-20 cm long, abruptly narrowed to an acute apex, more gradually narrowed or tapering at the base, glabrous above, almost imperceptibly scurfy-tomentose beneath, aciliate. Petioles scurfy. Flowers numerous in an umbel-like cluster, white to rose, not fragrant. Corolla rotate to campanulate, 3.5-4 cm dia. Stamens 10. Calyx lobes oblong, ovate, or subrotund, much longer than wide, commonly 2-4 mm long. Capsule oblong-cylindric, 1-1.5 cm long, stipitate-glandular. n = 13 (Sax 1930). June, July. Found in moist or wet woods. Often in dense colonies. Occurs widely in the western mountainous part of the state. (Fig. 1).
2. *Rhododendron catawbiense* Michx. Mountain Rose Bay. Purple Laurel. Rose Bay. Shrub or small tree up to 6 m tall. Twigs grey to reddish-brown, scurfy. Bud scales red-brown, slightly scurfy, glandular-ciliate. Leaves thick, coriaceous, evergreen, oval or elliptic, 5-15 cm long, broadest near the middle, rounded, obtuse, or subacute at both ends, sometimes subcordate at the base, abruptly pointed at apex, glabrous on both sides,

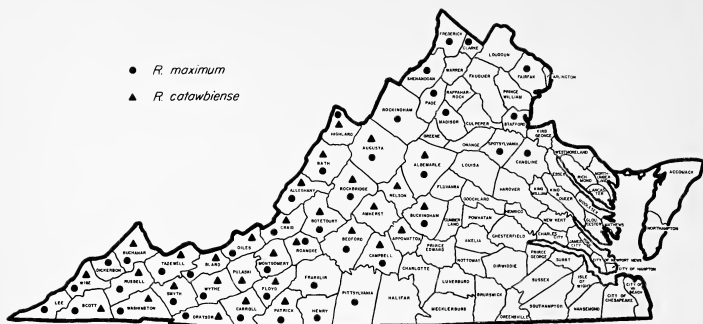


FIG. 1.—Distribution of *Rhododendron maximum* and *R. catawbiense* in Virginia by city and county.

aciliate. Midrib and petiole sparingly hirsutulous. Flowers in an umbel-like cluster, somewhat larger than those of *R. maximum*, rose-purple to lilac-purple, rarely white, not fragrant. Corolla rotate to campanulate, 6 cm dia. Pedicels and ovary hirsutulous, eglandular. Calyx lobes broadly triangular or semicircular, broader than long, less than 1 mm long. Capsule cylindric, 2–2.5 cm long, densely hirsute, eglandular.  $n = 13$  (Sax 1930). May, June. Occurs in mountain woods in western and southwestern part of state. (Fig. 1).

3. *Rhododendron calendulaceum* (Michx.) Torr. Flame Azalea. Yellow Azalea. Shrub up to 3 m tall, much branched. Twigs strigose with fine dense pubescence between the coarse hairs, gray-brown. Buds glabrous. Leaves oblong to obovate or oblanceolate, thin, not coriaceous, ciliate, finely pubescent above and more densely so beneath when young, particularly on and along the midrib, not yet fully grown at anthesis, eventually 5–10 cm long, about half as wide; petioles pubescent. Flowers in clusters of 5–15, expanding with or shortly after the leaves, yellow or orange to scarlet with orange blotch on the upper lip of the corolla, not fragrant. Corolla over 5 cm dia, funnel-form, pubescent and glandular-pilose on the outside, glabrous inside. Pedicels setulose, stipitate-glandular. Stamens 5, about three times as long as the corolla tube. Calyx lobes oblong-ovate, glandular-ciliate, 2–3 mm long. Capsule setose, eglandular, ovoid-oblong, 1.5–2 cm long.  $n = 26$  (Sax 1930). May. Confined to the mountainous region in the western part of the state. (Fig. 2).

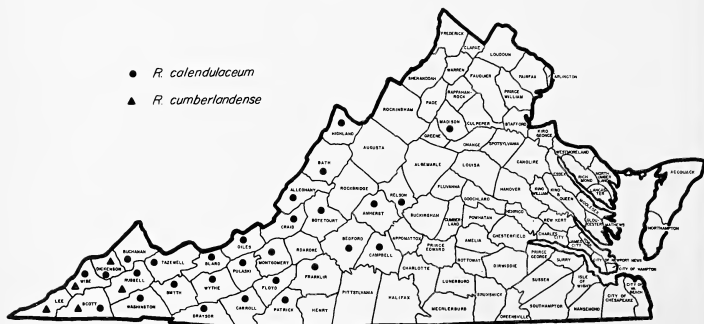


FIG. 2.—Distribution of *Rhododendron calendulaceum* and *R. cumberlandense* in Virginia by city and county.



4. *Rhododendron cumberlandense* Braun. Red Azalea. Cumberland Azalea. Compactly branching stoloniferous shrub up to 3 m tall but usually low growing. Twigs yellow-brown, sparsely strigose or otherwise glabrous. Buds glabrous, yellow-brown; outer scales aristate with awn as long as body of scale. Leaves narrowly obovate, 3–5 cm long, less than half as wide, ciliate, thin, not coriaceous, glabrous, full grown at anthesis; midrib strigose with fine whitish pubescence above and sparing strigose and finely pubescent beneath; petiole strigose, pubescent. Flowers several in a short raceme, orange-red to red; not fragrant. Corolla 5 cm or less in dia, funnel-form, pubescent with short almost sessile glands outside, glabrous inside, the upper lobe of the corolla much wider than the others and marked with a large orange spot. Pedicels strigose. Calyx lobes round-ovate, glandular-ciliate, less than 1 mm long. Stamens 5, three times as long as the corolla tube. Capsule 2 cm long, ovoid, strigose, eglandular.  $n = 13$  (Li 1957). June, July. Cumberland and Kanawha Plateaus of southwestern Virginia. (Fig. 2).
5. *Rhododendron nudiflorum* (L.) Torr. Wild Azalea. Early Azalea. Pinksterflower. Honeysuckle. Pinxterbloom. Shrub up to 2 m tall, branched above. Twigs dull brown or grayish-brown, sparingly strigose. Buds glabrous or slightly pubescent, brown, with ovate, abruptly acuminate scales. Leaves elliptic to obovate, 5–10 cm long, thin, ciliate, not coriaceous, not fully expanded at anthesis, glabrous or slightly strigose; midrib finely pubescent above and strigillose below; petioles strigillose. Flowers appearing before or with the leaves, in clusters of 6–12, white to pink or pinkish-purple, not fragrant. Corolla funnel-form, 3–4 cm dia, finely pubescent and hirsute to stipitate-glandular outside, sparsely hirsute inside tube. Stamens 5, about three times as long as the corolla tube. Pedicels strigose-pilose, pubescent, rarely stipitate-glandular. Calyx lobes semi-orbicular or ovate, long ciliate, 0.5–2 mm long. Capsule oblong to narrow-oblong, finely pubescent, strigose, eglandular, 1–2 cm long.  $n = 13$  (Li 1957). Late April, May. Moist or dry woods or bogs. Widespread throughout the state. (Fig. 3).
6. *Rhododendron atlanticum* (Ashe) Rehder. Dwarf Azalea. Coast Azalea. Low stoloniferous shrub rarely more than 0.5 m tall, with slender upright usually sparingly branched or simple stems. Twigs reddish-brown at end of first season, glabrous to sparingly strigillose and sometimes setosely glandular. Buds light brown, glabrous or slightly silky pubescent, white ciliate. Leaves obovate to oblong-ovate, 3–6 cm long, thin, setosely ciliate, not coriaceous, glabrous above except sometimes stipitate-glandular; glabrous or stipitate-glandular below; midrib villous above, sparingly strigillose and sometimes pubescent and/or stipitate-glandular beneath; petioles sparingly strigillose or stipitate-glandular. Flowers appearing with or before the leaves in clusters of 4–10, white, usually flushed pink or purple outside, very fragrant. Corolla funnel-form, about 4 cm dia, with stipitate glands arranged along the midveins of the lobes, glabrous inside. Pedicels hirsute or glandular-hirsute. Stamens 5, twice as long as the corolla tube. Calyx lobes broadly ovate, usually glandular-ciliate, 2–4 mm long. Capsule ovoid-oblong, glandular-setose, 1.5–2 cm long.  $n = 13$  (Li 1957). April, May. Sandy soil on the coastal plain. Characteristic of the low pine lands where it forms extensive colonies. (Fig. 4).
7. *Rhododendron roseum* (Loisel.) Rehder. Election Pink. Early Azalea. Mountain Azalea. Roseshell Azalea. Shrub up to 5 m tall, with irregularly whorled branches. Twigs grayish-brown to light brown, finely pubescent and sparingly strigose. Buds grayish pubescent. Leaves elliptic or obovate to obovate-oblong, thin, ciliate, not coriaceous, usually eglandular but sometimes with stipitate glands, sparingly pubescent above, densely grayish villous beneath; midrib pubescent above and sparingly strigillose beneath; petioles soft-

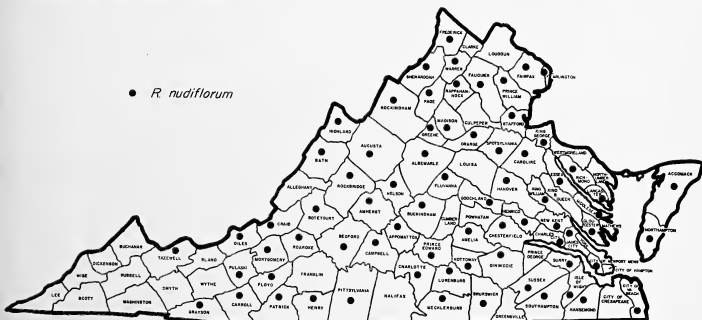


FIG. 3.—Distribution of *Rhododendron nudiflorum* in Virginia by city and county.

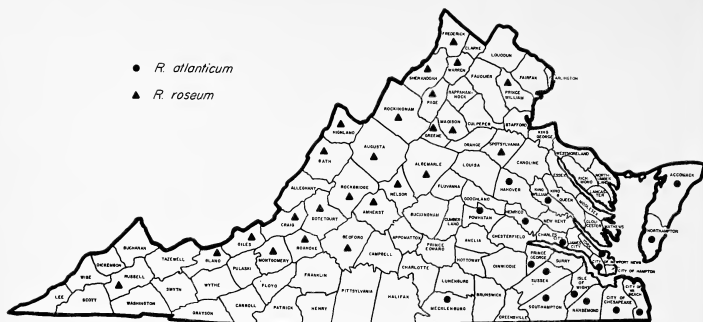


FIG. 4—Distribution of *Rhododendron atlanticum* and *R. roseum* in Virginia by city and county.

pubescent, sparingly strigose. Flowers in clusters of 5–9, bright pink to magenta, expanding with the leaves, with clove pink fragrance. Corolla funnel-form, 4–5 cm dia, covered with thin villous tomentum with stipitate glands distributed generally, pilose inside. Stamens 5, twice as long as corolla tube. Pedicels finely villous and glandular-setose. Calyx lobes semiobicular to ovate, finely pubescent, glandular-ciliate, rarely over 1 mm long. Capsule oblong, sparingly puberulous and glandular-setose, 1.5–2 cm long.  $n = 13$  (Sax 1930). May. Moist or dry woods in the western mountainous part of the state. (Fig. 4).

8. *Rhododendron canescens* (Michx.) Sweet. Wild Azalea. Shrub to 4 or 5 m tall with irregularly whorled upright branches. Twigs yellow-brown, finely pubescent and sparingly strigose. Buds densely grayish pubescent. Leaves oblong-ovate to oblanceolate or oblong, 4–9 cm long, thin, setosely ciliate, not coriaceous, sparingly pubescent above, densely pubescent or grayish tomentulose beneath particularly on the veins and midrib; midrib finely villous above, densely pubescent and sparingly strigose toward the base beneath; petioles finely pubescent and sparingly strigose. Flowers pink, in clusters of 6–15, expanding with or before the leaves, slightly fragrant. Corolla funnel-form, about 4 cm dia, densely and finely villous and stipitate-glandular, rarely somewhat pilose outside, pubescent inside. Stamens 5, three times as long as the corolla tube. Pedicels densely and finely pubescent, stipitate-glandular. Calyx lobes unequal, semiobicular to ovate, ciliate or glandular-ciliate, scarcely more than 1 mm long. Capsule cylindric-oblong, pubescent, sparingly setose, eglandular, 1.5–2 cm long.  $n = 13$  (Li 1957). April, early May. Moist woods on the coastal plain, also scattered occurrence in other physiographic provinces. (Fig. 5).

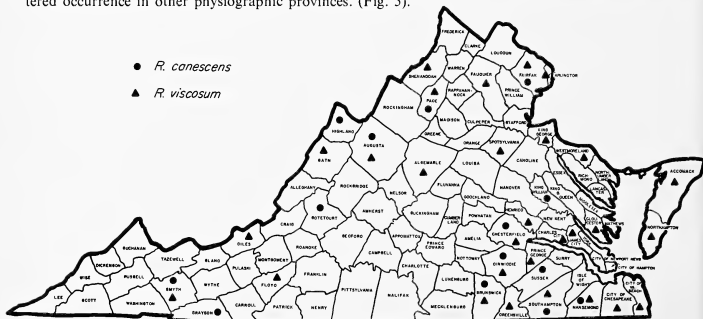


FIG. 5—Distribution of *Rhododendron canescens* and *R. viscosum* in Virginia by city and county.

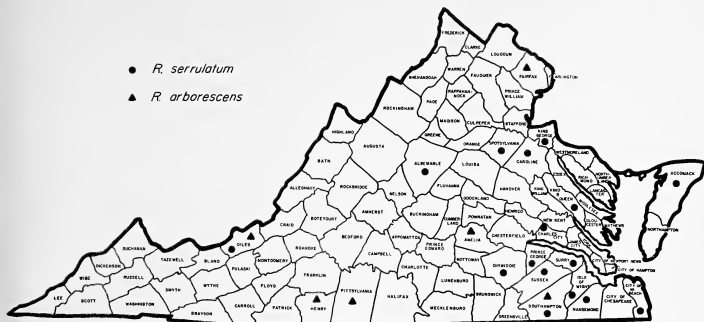


FIG. 6.—Distribution of *Rhododendron serrulatum* and *R. arborescens* in Virginia by city and county.

9. *Rhododendron viscosum* (L.) Torr. Swamp Honeysuckle. Swamp Azalea. Shrub, usually much branched, 1–3 m tall. Twigs yellowish-brown or grayish brown, hirsute or strigose. Buds with pale brown glabrous or pubescent scales with no dark marginal band. Leaves oblanceolate to obovate, 3–6 cm long, thin, ciliate, not coriaceous, glabrous; midrib very slightly villous above, more or less strigose beneath; petioles strigillose. Flowers white, rarely pink, in clusters of 4–9, appearing after the leaves, fragrant. Corolla funnel-form, 1–3.5 cm dia, stipitate-glandular and minutely pubescent outside, slightly pubescent inside above the middle. Stamens 5, about twice as long as the corolla tube. Calyx lobes semi-orbicular to ovate, setosely glandular-ciliate, about 1 mm long. Pedicels stipitate-glandular and minutely pubescent. Capsule oblong-ovoid, glandular-setose and finely pubescent, or sometimes glandless, 1–3 cm long.  $n = 13$  (Li 1957). June, July. Wet woods and swamps scattered throughout the state. (Fig. 5).
10. *Rhododendron serrulatum* (Small) Millais. Tall shrub or small tree up to 7 m tall. Twigs bright red-brown, copiously strigose and finely villous. Buds with pale scales with conspicuous dark margin, glabrous or sometimes grayish pubescent. Leaves elliptic to obovate or obovate-oblong, 3–8 cm long, thin serrulate-ciliate, not coriaceous, glabrous above and beneath; midrib sparingly short-villous above and strigose beneath; petioles strigose. Flowers white, in clusters of 6–10, appearing after the leaves, very fragrant. Corolla funnel-form, 2–3 cm dia, stipitate-glandular and minutely pubescent outside, glabrous inside. Stamens 5, one and one-half times as long as the corolla tube. Calyx lobes semi-orbicular to ovate, glandular-ciliate, rarely over 1 mm long. Pedicels stipitate-glandular and minutely pubescent. Capsule ovoid-oblong, minutely villous and densely glandular-setose.  $n = 13$  (Li 1957). June. Wet woods on the coastal plain and scattered occurrence elsewhere. (Fig. 6).
11. *Rhododendron arborescens* (Pursh) Torr. Smooth Azalea. Tall shrub or small tree up to 6 m tall. Twigs yellowish to light grayish-brown, glabrous. Buds glabrous. Leaves oblanceolate, 3–8 cm long, thin, ciliate, not coriaceous, glabrous, midrib sparingly short villous above and sparingly strigose beneath; petioles glabrous. Flowers white to pinkish, in clusters of 3–6, appearing after the leaves, very fragrant. Corolla funnel-form, 3–4.5 cm dia, sparingly stipitate-glandular, otherwise glabrous outside, pubescent inside in upper two-thirds. Stamens 5, twice as long as corolla tube. Calyx lobes ovate to linear-oblong, glandular-ciliate, 3–6 mm long. Pedicels glandular-hirsute, otherwise glabrous. Capsule oblong-ovoid, densely glandular-hispid, 0.8–1.7 cm long.  $n = 13$  (Sax 1930). June, July. Upland woods, especially in the mountains. (Fig. 6).

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Manuscript received January 2, 1975  
Revised manuscript received April 11, 1975

## A Computer Simulation Model of a Multispecies Centrarchid Population Complex\*

**Abstract**—The development and structure of STOCKS, a computer simulation model of a multispecies centrarchid population complex, is discussed. STOCKS emphasizes dynamic interrelationships among three game fishes: bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*). Required input data for each species are: (1) an initial population estimate; (2) estimated high, medium, and low annual recruitment with a standard deviation for each; (3) annual natural mortality rate; and (4) annual fishing mortality rate. Simulator output is: (1) a population estimate for each species each year; (2) catch of each species for each year; and (3) mean catch of each species for all years. Analysis of a large number of computer runs under various input conditions is discussed. STOCKS is not offered as the solution to the multispecies management problem, but rather as an approach to better understanding the dynamics of centrarchid population complexes.

Effectively managing multispecies fish population complexes is a perpetual enigma in fisheries management. Successfully managing a single species is difficult at best, but managing a complex with two, three, or more competing populations is a formidable, if not impossible, task (Lackey 1974). To enhance understanding of fisheries and thereby increase management capabilities, mathematical models have been formulated which attempt to describe how populations function. Some of these models have become classical tools in fisheries management. Unfortunately, none of the models is particularly applicable in multispecies situations which are characteristic of nearly all freshwater and marine fisheries. The classical models best apply to single species fisheries as found in a few marine commercial situations. For example, the Ricker (1954) stock recruitment model applies to a population where fish spawn once and die, as with the Pacific salmon.

The two best known single stock models are the dynamic pool model (Beverton and Holt 1957) and the logistic model (Schaefer 1954). The dynamic pool model describes a fish population in terms of the vital parameters of recruitment, growth, and mortality.

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Implementing this model requires a large amount of data and can generally be successful only after substantial information has been collected on a fish population. The logistic model, also called the surplus-yield model, combines the effects of recruitment, growth, and natural mortality into a single-valued function of population biomass. The logistic model, usually employed when information on a fish population is relatively scanty, requires only catch and effort data for a series of years.

Both the dynamic pool and the logistic models have been applied, with some success, in the management of marine commercial fisheries. The dynamic pool model has been used in the North Sea plaice fishery and provides an adequate description of the fishery (Gulland 1972). The logistic model has been useful in managing the Eastern Tropical Pacific yellowfin tuna fishery (Schaefer 1957, Gulland 1972). Neither, however, has been applied with much success in freshwater sport fisheries. Watt (1959) did an extensive study of the smallmouth bass population of South Bay, Lake Huron. He applied four different population models to the fishery, including the logistic and dynamic pool models, and found that all models were deficient in one or more respects. He attributed the weaknesses of the models to lack of adequate input data. He had "relatively small amounts of information collected over only a ten year period" (emphasis added). In comparison to data available on most freshwater sport fisheries, Watt had an abundance of information. Watt's conclusion illustrates one of the main problems with classical population models: to be accurate predictive tools they simply require more data than are available from most sport fisheries.

An additional problem with all commonly used fisheries models is the deterministic description of stochastic population phenomena. Models that incorporate stochastic processes may provide better descriptions of population dynamics. An example of deterministic versus stochastic processes should illustrate why the latter is to be preferred for sport fisheries. A deterministic model predicts that for a given value of the independent variable,  $X$ , we can expect the dependent variable to have a corresponding value,  $Y$ . A stochastic model predicts that for a given value of  $X$  we can expect any one of a number of  $Y_i$

values, with a probability of  $P_1$  attached to the occurrence of each  $Y_1$  (Watt 1959). The stochastic approach is appropriate where a steady state situation cannot be safely assumed, which is the case in most fisheries.

There are many computer-implemented stochastic fisheries models described in the literature. Royce et al. (1963) developed a simulation model to investigate economic and biological consequences of various strategies for restricting entry of gear into the salmon net fisheries. Larkin and McDonald (1968) used a computer simulation model to synthesize the main features of the population biology of sockeye salmon of the Skeena River. Paulik and Greenough (1966) used computer simulation for management analysis of a salmon resource system. Southward (1966) developed a large-scale simulation model to study three management strategies for limiting halibut catch in the northeastern Pacific. Mathews (1967) developed a simulation model to determine potential economic benefits to the canning industry of varying degrees of forecast reliability of the size of sockeye salmon runs to Bristol Bay, Alaska. Pella (1968) employed Monte Carlo simulation techniques to study the effectiveness of mark-recapture experiments for estimating population parameters of tuna. Riffenburgh (1969) developed a stochastic model of inter-population dynamics based on energy flow through an ecological system composed of the Pacific sardine, the northern anchovy, and their competitors, predators, and prey. These models and others are discussed in more detail by Paulik (1969).

Large-scale models of marine commercial fisheries are not easily applicable to a freshwater sport fishery. Walters (1969) developed a general computer simulation model which may have application in sport fisheries, but the basic model structure is deterministic. Also, his model is designed to describe a single species population and, therefore, its predictive value in most freshwater fisheries is limited.

The purpose of this paper is to describe a stochastic population dynamics model which was designed to be generally applicable to multispecies freshwater sport fisheries. The model, STOCKS, is not offered as the panacea for multispecies management, but rather as a methodological approach to the problem.

### The Conceptual Model

STOCKS is based on a three-species freshwater centrarchid population complex. Much of the basis for the model was derived from 10 years of creel census data from Lake Brittle, Virginia. Each species is considered to be a single stock (a manageable unit in itself). The three stocks used in the model are black crappie (CR), largemouth bass (LMB), and bluegill (BG) (Fig. 1). Total size of the combined three stocks (N) is represented by the outer line. Crappie, bass, and bluegill were selected for modeling because of the readily available data on the population dynamics of these species. However, any three game fishes that meet the requirements of the model could have been used. The model in Fig. 1 is an extension of the unit stock model of Ricker (1958). Recruitment (R) acts to increase the total number of recruited fish in the fishery. Total annual natural mortality rate (D) and

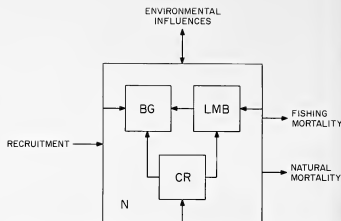


FIG. 1.—Conceptual model of a three-species fishery which is the basis for STOCKS.

fishing exploitation rate (E) act to decrease N. Environmental effects (V) either increase or decrease N, depending on whether the effects are favorable or unfavorable.

Since the model includes three stocks, there must be a mechanism to account for interspecific competition and predation. Interspecific competition and predation in STOCKS is based on spawning sequence and is predicated on the theory that density-dependent factors control animal populations (Nicholson 1933, 1954). Thompson (1941) describes a situation where a large year-class of crappie dominated the abundance of all fishes in a lake for the duration of the age class. Swingle (1950) has described how bass and bluegill interact to control each other. Bass and bluegill, although not strong competitors, may each curtail the population of the other (Bennett 1971). An assumption in STOCKS is that the population which first produces a strong year-class will have a competitive advantage over other species. Crappie spawn first (by water temperature), largemouth bass second, and bluegill last (Calhoun 1966). There is some overlap (i.e., crappie are still spawning when largemouth bass begin spawning) but spawning times are distinct enough to be considered discrete. If crappie exhibit high spawning success, they will exert a controlling effect over the spawning success of largemouth bass and bluegill. In turn, the spawning success of largemouth bass affects the spawning success of bluegill. The spawning success of bluegill does not directly affect spawning of either crappie or largemouth bass, but does have an indirect effect in that it contributes to N, which affects future spawning success of all three stocks.

Growth in biomass per individual is not considered explicitly in STOCKS, only increase in numbers. For a simulator with general application it is more practical to deal with numbers of fish rather than individual growth rates. Average sizes for each species vary substantially from fishery to fishery and only a few realistic situations could be easily incorporated into a simulator. Rather, the user should consider the model to be operating under the average conditions of a particular fishery and assume that the results reflect these conditions. For example, the catch of

bluegill predicted by STOCKS for a given year should be considered as comprising average size bluegills found in that body of water in an average year. If stunting occurs, STOCKS provides a statement to this effect in the output. In practice, stunting (extreme overpopulation as shown by STOCKS) is rare, and generally happens only when the initial population estimates are very high.

### The Computer Simulator

#### Program Structure

STOCKS is coded in FORTRAN IV on an IBM System 370. A fully documented program listing and user guide is available from the authors. The simulator comprises a main program and five subroutines. The main program serves to read in data, call various subroutines, and write out results. The program iterates on a daily basis for a simulation of 10 years.

The first subroutine, RC, generates recruitment for each stock. Recruitments are generated from the following functions:

$$\begin{aligned} R_{cr} &= f(N), \\ R_{lm} &= f(N, R_{cr}), \text{ and} \\ R_{bg} &= f(N, R_{cr}, R_{lm}). \end{aligned}$$

This subroutine incorporates a process generator which generates values for recruitment from a normal distribution. The process generator provides stochastic rather than deterministic recruitment values. There are three possible recruitment distributions for each stock: high, medium, and low. The user (manager) must provide high, medium, and low recruitment values. Interaction between stocks in the main program determines from which distribution the recruitment will be generated for each year. The RC subroutine is provided with the mean and standard deviation of the appropriate distribution, and from this it generates recruitment within three standard deviations of the mean. For example, suppose it is determined that the current year will produce a high recruitment of crappie. The mean for the high recruitment value and corresponding standard deviation that were read in as input data are sent to the RC subroutine. Suppose these values are 30,000 and 5,000 respectively. The RC subroutine will generate a recruitment from a normal distribution with mean 30,000 and standard deviation 5,000, within the limits of three standard deviations. A value for recruitment will be generated from the interval 15,000 to 45,000, and 68% of the time the value will be within one standard deviation of the mean (25,000–35,000).

The F subroutine estimates the number of fish in each stock that die due to fishing on a given day, us-

ing instantaneous rates. The total number of fish of each stock alive on a given day is then multiplied by the daily fishing mortality rate to obtain the number of fish in each stock that died due to fishing on that day. These values are returned to the main program where they are subtracted from the current population size.

The M subroutine estimates the number of fish in each stock that die due to natural mortality on a given day by converting annual rates to daily rates. The number of fish in each stock alive on a given day is multiplied by the daily rate and the results are subtracted from the current values of each stock.

RANDU, the fourth subroutine, is the random number generator. It generates a uniformly distributed random number on the interval (0.0, 1.0). RANDU is used in the RC subroutine to provide random numbers required by the normal process generator. RANDU is also used in the main program as one determinant of the level of recruitment.

TPLLOT is the final subroutine and it plots catch of each stock over 10 years (three separate graphs). The plot routine is optional and must be requested.

#### Input Data Required

The type of input data selected was in part determined by what could be realistically expected from a reasonably well-studied fishery. Detailed instructions describing input data requirements are given in the program listing available from the authors.

The user is required to enter a 5-digit, odd, random number. This number sets the random number generator which then generates all the random numbers called for in the program. More sophisticated means could be used to seed RANDU (e.g., calling the number from the computer system clock), but giving the user control over the initial random number has a distinct advantage. When the user wishes to experiment with the simulator, he can make various runs by adjusting different system parameters, while holding the random number constant. The whole series of random numbers generated in the simulator will remain the same and changes in output can be attributed to the specific variables that were manipulated.

An initial population estimate of each stock present at the end of the last angling season must be provided because simulation begins by adding recruitment for the first year to the initial population estimate.

The user must also provide high, medium, and low estimates of the mean annual recruitment for each stock, with a standard deviation for each. A simple way of determining the approximate standard devia-

TABLE I  
Results of testing STOCKS with selected initial random numbers (table values are estimated 10-year average catch of each stock)

Stock	Random Number					
	12693	15973	45239	78965	53261	99999
Bluegill	7,423	8,182	7,729	6,622	7,259	6,161
Largemouth Bass	176	150	188	121	205	94
Crappie	11,046	10,425	10,958	12,101	9,699	11,814



TABLE 2

Results of testing STOCKS with high, medium, and low initial population estimates

Stock	Initial Population Estimate	10-Year Average Catch
Bluegill	10,000	15,230
	50,000	17,224
	80,000	16,981
Bass	100	204
	750	275
	2,000	251
Crappie	5,000	11,314
	40,000	11,161
	70,000	12,524

tion is to estimate the range of the distribution in which 95% of the possible values is included. This range is approximately four standard deviations and one-fourth of this range equals one standard deviation. For example, suppose mean annual high recruitment of bluegill in a particular fishery is estimated to be 50,000 fish. The extremes are grossly estimated to be 30,000 and 70,000. Thus, the range is 40,000 with an approximate standard deviation of 10,000. The user enters 50,000 for the mean high recruitment and 10,000 for the high recruitment standard deviation. The same procedure is followed for the high, medium, and low recruitment values for all three stocks.

The proportion of each stock that will be removed each year due to natural mortality must also be estimated. If it is estimated that 40% of the crappie stock will die due to natural mortality each year, then .40 is entered on the data card. The estimates of annual fishing mortality,  $E$ , for each stock are determined in the same manner. If  $E$  for bluegill is 25% then .25 is entered on the data card.

### Analysis of Simulator Runs

Numerous simulation runs were made with STOCKS during its development and after its completion. The simulator was tested at the extremes, such as using zero population estimates, and at extraordinarily high population estimates. It was also tested with various combinations of recruitment and mortality estimates. Simulation runs were also extended to 100 years to determine performance over an extended time frame. STOCKS performed acceptably; i.e., it delivered output values that appeared realistic as compared to Lake Brittle data. STOCKS

was also tested for sensitivity to variations in input parameters.

### Sensitivity Analysis

Six different initial random numbers were tested while holding other system components constant. The model was relatively insensitive to different random numbers as ascertained by comparisons of the 10-year average catch of each stock (Table 1). The variation in catch due to the random number is roughly similar to actual catches from Lake Brittle.

Three initial population estimates were tested to determine how their magnitude affected average catches (Table 2). Initial population estimates had little effect on the overall average catch. This is a highly desirable property because it affords the user a large margin for error in making initial population estimates.

The level of the recruitment estimates has a more profound effect on average catch than does the random number or the initial population estimate. Recruitment estimates and average catch appear to vary in direct proportion; that is, a 10% decrease in recruitment decreases average catch approximately 10%, while a 10% increase in the recruitment increases average catch approximately 10%. Standard deviations must be adjusted in proportion to the adjustment in the recruitment estimate if the proportional relationship is to hold for all cases. Based on these results, the user should attempt to provide the best possible estimate of recruitment.

The model was tested for reaction to simulated changes in fishing mortality by varying fishing mortality of one stock from a very low to a very high value while holding the parameters of the other two stocks constant. Bluegill exploitation was varied from .10 to .70 while holding largemouth bass exploitation at .25 and crappie exploitation at .10 (Table 3). Largemouth bass exploitation was varied from .10 to .75 while holding bluegill exploitation at .30 and crappie exploitation at .10 (Table 4). Crappie exploitation was varied from .10 to .70 while holding bluegill exploitation at .30 and largemouth bass exploitation at .25 (Table 5). In every case catch increased until  $E = .50$  and then declined. This response is not unexpected because one of the assumptions of the model is the parabolic relationship of yield on fishing effort as exemplified in the logistic model (Royce 1972). If some other assumptions were warranted, STOCKS could be modified to reflect another relationship. The model was tested to determine the effect of simulated fishing of all three stocks at  $E = .50$ . The result was a higher yield of each stock

TABLE 3

Results (expressed as catch) of testing STOCKS by varying bluegill exploitation rate from .10 to .70 (other parameters constant with  $E = .25$  for largemouth bass and  $E = .10$  for crappie). Each column represents a 10-year simulation at a particular  $E$  level

Stock	Exploitation Rate for Bluegill						
	.10	.20	.30	.40	.50	.60	.70
Bluegill	7,423	13,495	17,224	19,933	24,180	18,438	19,534
Largemouth Bass	242	245	275	291	286	459	459
Crappie	11,046	11,161	11,161	11,493	12,616	11,099	11,099

TABLE 4

Results (expressed as catch) of testing STOCKS by varying largemouth bass exploitation rate from .10 to .75 (other parameters constant with  $E = .30$  for bluegill and  $E = .10$  for crappie). Each column represents a 10-year simulation at a particular  $E$  level

Stock	Exploitation Rate for Largemouth Bass						
	.10	.25	.30	.40	.50	.60	.75
Bluegill	17,224	17,224	17,224	17,224	17,224	26,228	26,228
Largemouth Bass	145	275	305	353	390	108	116
Crappie	11,161	11,161	11,161	11,161	11,161	10,514	10,514

as compared to any other combination of exploitation rates tested.

Natural mortality was not tested for two reasons. First, it operates in the same mode as fishing mortality in the simulator and will cause similar trends in catches. Secondly, in most management situations, natural mortality is only slightly under the control of the fisheries manager. Therefore, to vary it in simulation would not be very realistic. The best estimate of natural mortality for each stock should be obtained and then held constant;  $E$ , which is under control of the manager, can be varied.

### Validation

One approach to validation is to assume that a model is valid if, despite its inexactness in representing the system, it can give a reliable prediction of the system's performance (Taha 1971). In freshwater sport fisheries it is probably currently impossible to validate a model according to this definition because adequate data are lacking. Data that are available are generally used in developing the model and thus cannot be used to validate it. In the case of STOCKS, the model was based on 10 years of creel census data from Lake Brittle and thus cannot be validated by using the same Lake Brittle data.

Although the model cannot be validated, its performance in relation to the Lake Brittle system can be examined (Figs. 2, 3, and 4). Closer correlation between the real and model catches could be obtained by varying the combinations of input parameters, but such an effort would not validate the model.

### Discussion

The key results from the analysis of many runs of STOCKS are: (1) the proportional relationship of recruitment and catch in the model; (2) the effect of varying exploitation of one stock on the catch of the other stocks; (3) an indication of the exploitation

level which produces the maximum sustainable yield; and (4) the graphical analysis showing that STOCKS may possibly mimic a multispecies population complex.

The average catch of a stock was found to be about proportional to the recruitment values specified for that stock as input data. This relationship may prove useful for discovering what the average recruitment levels really are since it is difficult to get accurate population estimates, much less good estimates of recruitment in most fisheries. Perhaps through use of the proportional recruitment relationship we can address the problem in a different manner. For example, the manager designs a strategy to obtain good estimates of natural and fishing mortality for each stock. He then uses these estimates in the simulator along with his best intuitive estimates for recruitment and initial population levels. He runs the simulation to estimate average catches for each stock and then compares these to average catches on the fishery. If the simulated catches are low compared to actual catches, he would increase input recruitment values and rerun the simulator. He would continue iterating until the simulated catch approximated the real catch level. He should finally arrive at a reasonable approximation to the recruitment values. Once he has recruitment values, he can then begin to experiment with the simulator by varying exploitation.

The response of STOCKS to varying exploitation rate for one stock while holding the others constant appears to verify interaction effects. When a stock was increasingly exploited, the average catch of that stock increased until the level of overexploitation was reached, and then the catch took a drastic decline (Tables 3, 4, and 5). Concurrently, the catches of the other two stocks were not significantly affected until the stock which was being increasingly exploited reached an overexploitation level. Catches from one of the two other stocks would increase sharply and act to exert control over the third stock. This can be seen by following the exploitation sequences through the tables.

TABLE 5

Results (expressed as catch) of testing STOCKS by varying crappie exploitation rate from .10 to .70 (other parameters constant with  $E = .30$  for bluegill and  $E = .25$  for largemouth bass). Each column represents a 10-year simulation at a particular  $E$  level

Stock	Exploitation Rate for Crappie						
	.10	.20	.30	.40	.50	.60	.70
Bluegill	17,224	18,722	19,356	18,466	19,979	18,671	18,671
Largemouth Bass	275	302	327	285	279	674	674
Crappie	11,161	21,645	26,658	32,699	36,457	16,052	17,301

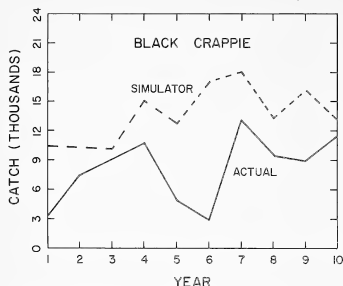


FIG. 2—Plot of STOCKS-generated crappie catches vs. Lake Brittle crappie catches.

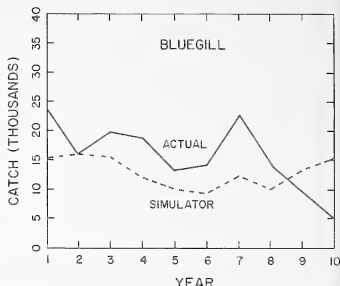


FIG. 4—Plot of STOCKS-generated bluegill catches vs. Lake Brittle bluegill catches.

A key question in fisheries management is how to optimize output (however it is to be defined) from each stock at the level of maximum sustainable yield. If we assume that all fish in the creel are approximately equally desirable, then all stocks should be exploited at  $E = .50$ . But, in reality, would this strategy work? Perhaps if all three stocks were fished at this level, predation on and/or competition with bluegill, for example, would be reduced to a low level. In this situation the bluegill stock may increase tremendously, causing stunting and thereby decreasing yield in the long run. Perhaps a better strategy would be to fish one of the highly reproductive stocks for maximum sustainable yield and fish the other stocks at some lower level. Or, perhaps none of the stocks should be fished at maximum sustainable yield but at some intermediate level which would result in the highest total yield. STOCKS indicates that the intuitive answer may apply in this case.

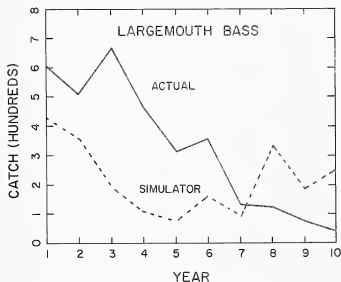


FIG. 3—Plot of STOCKS-generated largemouth bass catches vs. Lake Brittle largemouth bass catches.

Simulations were based on the aforementioned strategies and showed that fishing all three stocks simultaneously at the maximum sustainable yield provides the maximum yield of each over the long run. This is not surprising, considering the reproductive potentials of the species and the fact that most of the catch is represented by one year-class. Larkin (1963), using the Lotka-Volterra equations (Lotka 1932, Volterra 1931) to explore competitive interactions between two species, also found that the yield of either species is greater in any set of conditions when its competitor is also harvested.

Validation of a computer simulation model is important in any discipline. Any model can be made to deliver the desired results by appropriate manipulations of its parameters. Although we can show graphically that a model may mimic the real system, the key question is not merely whether the output from the model looks good but whether it meets the management objectives of allowing a choice among various relevant decisions or identifying weaknesses in existing knowledge.

Currently STOCKS can only be used to simulate three relatively discrete stocks. This of course limits the complexity of the fishery to which STOCKS would be applicable. If the fishery is so complex that there are perhaps two discrete stocks of largemouth bass, for example, the simulator must be modified. The simulator can, however, be used for a one- or two-stock system by simply entering zero values for the input parameters of the other stock or stocks. The other significant limitation is the restriction of the simulator to a discrete spawning sequence, or a sequence that overlaps to such a minor degree that it can be considered discrete. Modifications to account for this should not be difficult if the overlap is reasonably well understood.

STOCKS is not presented as the solution to the multispecies management problem, but rather as a foundation on which to build. It demonstrates one approach to the multispecies problem, a problem that cannot easily be solved (if it can be solved at all) with

a system of deterministic equations. STOCKS currently simulates a small sport fishery population complex, but this application can be expanded and refined as better data on population dynamics are collected. STOCKS provides a way to put new data to immediate use and in the process should help to guide efforts to collect further appropriate data.

STOCKS and similar simulators provide a heuristic device by which the fisheries manager may gain insight into the workings of a fishery. By manipulating input parameters he can observe how populations may respond and perhaps test a "best" simulator strategy in the real world and evaluate if populations respond as the simulator predicted. The heuristic value to the fisheries manager is limited only by his imagination.

Finally, STOCKS may be used in training students to be fisheries managers. STOCKS can easily be developed into a teaching game such as TROUT (Titlow and Lackey 1973) or DAM (Titlow and Lackey 1974). Thus, the problem of multispecies management can be brought into the classroom where future managers may get some idea of the complexities involved in managing fisheries resources.

**Acknowledgments**—Financial support for this project was provided by the Virginia Commission of Game and Inland Fisheries and the Fish and Wildlife Service, United States Department of the Interior.

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Manuscript received February 5, 1975

Revised manuscript received April 11, 1975

## Eutrophic Gradient in Smith Mountain Lake, Virginia

**Abstract**—Smith Mountain Lake is the storage reservoir of the Smith Mountain-Leesville Pumped-Storage Hydroelectric Project located on the Roanoke and Blackwater Rivers, near Roanoke, Virginia. Due to the continuous introduction of municipal industrial effluents into the Roanoke River as it passes through the Roanoke Metropolitan Area, the headwaters of the Roanoke River Arm of the lake have become eutrophic. Employing the standard techniques for measuring primary production rates, chlorophyll-a concentrations, transparency and light penetration, and percent saturation of dissolved oxygen, it was confirmed that the headwaters of the Roanoke River Arm do exhibit symptoms of eutrophy, and that there was a demonstrable gradient from eutrophic to mesotrophic conditions from the lake headwaters toward the Smith Mountain Dam.

### Introduction

Lakes and reservoirs are not permanent features of the landscape, for through the process of natural aging impounded bodies of water are ultimately destined to fill with organic and inorganic sediments and to become extinct (Hutchinson 1957, Sawyer 1966). Natural aging of lakes and reservoirs can be materially hastened by the introduction of nutrient enriched discharges from the watershed, the resulting changes in the rate of aging being commonly referred to as artificial or cultural eutrophication (Hasler 1947).

Although cultural eutrophication has been often defined, Bartsch (1970) quoted the following "working definition" agreed upon by the Eutrophication Group of the Organization for Economic Cooperation and Development: "Eutrophication is the nutrient enrichment of waters, which frequently results in an array of symptomatic changes, among which increased production of algae and other aquatic plants, deterioration of fisheries, deteriora-

tion of water quality, and other responses, are found objectionable and impair water use."

### Description of the Study Area

Smith Mountain Lake is the storage reservoir of the Smith Mountain-Leesville Pumped-Storage Hydroelectric Development located southeast of Roanoke, Virginia. The Smith Mountain Dam impounds the water of the Roanoke and Blackwater Rivers to form a lake of approximately 20,000 acres. The dam was completed in 1964, and minimum pool height in the reservoir was reached in 1965.

In a limnological study of Smith Mountain Lake, Simmons and Neff (1969) indicated that the lake was showing signs of eutrophy in the upper reaches of the Roanoke River Arm in 1966 and 1967 as evidenced by high carbon assimilation rates and severe hypolimnetic oxygen depletion in early spring and summer. Jennings et al. (1970) presented evidence on fish mortalities, nutrient enrichment, algal cell numbers, chlorophyll-a determinations and dissolved oxygen saturation levels, and concluded that the Roanoke Arm of the lake was definitely tending toward eutrophy. Both studies attributed the condition of the Roanoke River Arm of the lake to the influx of municipal-industrial wastes from the Roanoke Metropolitan Area.

The Roanoke River Arm is about 30 miles long, and the major municipal-industrial discharges are into the Roanoke River about 20 miles upstream from the lake headwaters. Because the river probably acts as a "point-source" discharge in terms of waste loading into the lake headwaters, the possible existence of a definable gradient of eutrophy was hypothesized and investigated in this study.

### Methods

Nine stations were established on Smith Mountain Lake: five on the Roanoke River Arm (Stations 5 to 9), one on the Blackwater Arm (Station 4), one at the

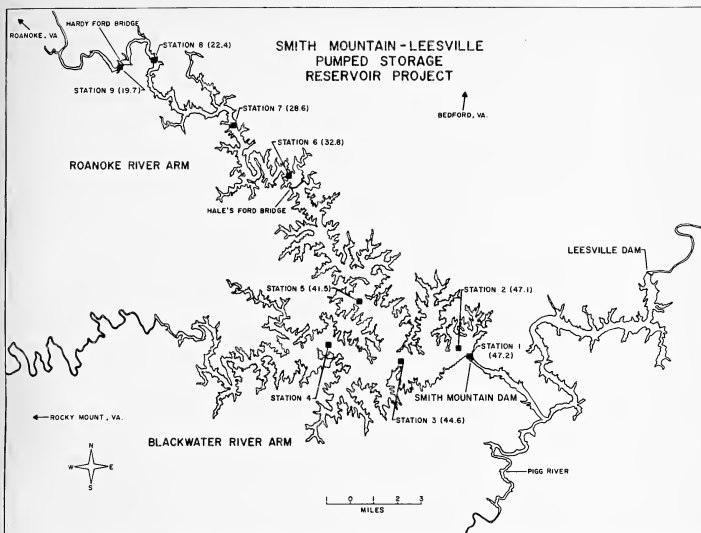


FIG. 1.—Map of the Smith Mountain-Leesville Pumped Storage Reservoir Project. Numbers in parentheses show approximate river miles downstream from Roanoke, Virginia.

confluence of the Roanoke and Blackwater (Station 3), and two (Stations 1 and 2) between the confluence and the Smith Mountain Dam (Figure 1). The stations were positioned such that the "eutrophication gradient" presumed to occur in the Roanoke River Arm (Stations 5 to 9) could be delineated and compared with the reference stations (1 to 4). Each station was visited 6 to 12 times between July 1971 and July 1972. During each visit the following limnological parameters were measured: primary production rates, chlorophyll-*a* concentrations, temperature, dissolved oxygen, pH, total alkalinity, transparency and light penetration.

Vertical water temperature profiles were measured at 1 m intervals with a dissolved oxygen-temperature meter (YSI Model No. 5525). Lake transparency was measured with a standard Secchi disc, and depth of 1% light penetration with a submarine photometer (G. M. Mfg. and Instrument Co.).

Water samples at nine depths (Surface to 8 m) for determination of chlorophyll-*a* concentration, total alkalinity, pH, and dissolved oxygen were collected using a Jobsco Water Puppy (Horizon Ecology Company) and a length of plastic pipe. All samples, with

the exception of those for dissolved oxygen which were fixed immediately for Winkler (Azide modification) determinations, were placed on ice for return to the laboratory. All laboratory analytical procedures were conducted according to APHA (1971).

Rates of primary production (carbon assimilation) were estimated using modifications of the methods outlined by Vollenweider (1971). Water was pumped from the desired depth into a blackened 500 ml flask. The same was carefully mixed, then divided into paired 125 ml BOD bottles (one clear and one painted silver on black) each containing  $1\mu\text{Ci}$  of  $\text{NaH}^{14}\text{CO}_3$ . The bottles were returned to the depths (Surface to 8 m) from which they were collected by means of a vertical suspension device of our own design composed of individual bottle holders constructed from 4.5" (OD) plastic sewer pipe couplings and steel springs, chained together in series (Figure 2). After a four hour incubation period, the string of samples was retrieved and immediately placed on ice in a light-proof box for return to the laboratory. In order to ensure the measurement of near maximum rates of production, the  $^{14}\text{C}$  incubation periods were

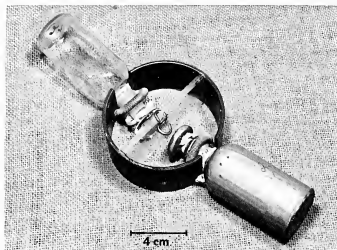


FIG. 2— $^{14}\text{C}$  bottle suspension unit with light and dark bottles in place.

restricted to the interval between 0900 and 1500 hours. Due to the distances involved (Stations 1 and 9 were about 30 miles apart), the stations were visited in groups of three on the sampling dates. As far as possible, all nine stations were visited within a seven day period.

In the laboratory, samples were filtered through  $0.45\ \mu$  millipore filters within 7 hours of the end of the incubation period. Filters were air dried and placed in vials containing 20 ml of Aquasol (New England Nuclear Company) for counting by liquid scintillation spectroscopy (Packard Tricarb Scintillation Spectrometer, Model 3310). Using the obtained counts and estimated total available carbon based on pH, alkalinity and temperature from the tables of Saunders, Trama, and Bachman (1962), carbon assimilation rates (primary productivity) were estimated according to the formulae of Vollenweider (1971).

## Results

### Seasonal Profiles of Primary Production and Attendant Parameters

Although carbon 14 assimilation rates and attendant parameters (chlorophyll-a, dissolved oxygen saturation, lake transparency and light penetration) were measured at all nine stations 6 or 7 times during the study year, data from four months (October, January, May and July) were chosen for presentation here to illustrate seasonal conditions in the system. The results are presented synoptically according to season.

**Fall (October 1971)**—Figure 3 shows that fall cooling had begun in October and thermal stratification was being disrupted throughout much of the lake due to cooling air temperatures and wind action. However, waters at the far upstream stations (8 and 9) retained rather strong thermal stratification.

Rates of primary production at all depths at Stations 1 to 3 were less than  $10\ \text{mg}/\text{m}^3/\text{hr}$  and chlorophyll-a concentrations did not exceed  $10\ \text{mg}/\text{m}^3$  (Figure 4). The rate of primary production at Station 4 was somewhat lower than at Stations 1 to 3,

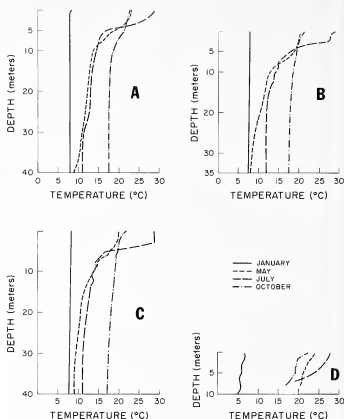


FIG. 3—Thermal profiles in Smith Mountain Lake during study period: (A) Station 2; (B) Station 4; (C) Station 5; (D) Station 9.

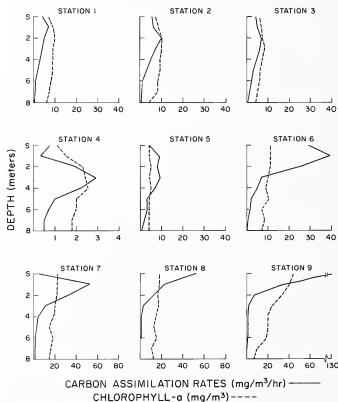


FIG. 4—Vertical carbon assimilation rates and chlorophyll-a concentration profiles during October 1971. Note the differences in scale on the x-axes.



as was chlorophyll-a concentration. In the Roanoke River Arm, rates of primary production and chlorophyll-a concentrations increased in an upstream direction and the shapes of the vertical profiles of the two measurements changed markedly. Slight surface inhibition was apparent at Stations 1 to 5, became more intense at Stations 6 and 7, but was completely absent at Stations 8 and 9. Peak rates of primary production were up to 13 times greater at the upstream stations than at the reference stations.

Percent saturation of dissolved oxygen in the surface waters of Stations 1, 2, 3, 7 and 8 approached 100% but was about 130% at Station 9 (Figure 5). In addition, Figure 5 shows that Secchi disc transparency and compensation point (depth of 1% light penetration) tended to decrease in depth in an upstream direction. By comparing Figures 4 and 5, it can be seen, at most stations, that the decline in depth of primary productivity coincided closely with the compensation point measured on the basis of light penetration.

*Winter* (January 1972)—Figure 3 shows that the lake was homeothermous at 7°C and was in complete circulation during January. Photosynthetic activity was substantially reduced throughout the lake, and the chlorophyll-a concentrations indicated smaller algal biomass than was present during October (Figure 6).

Oxygen content was near saturation at Stations 1 to 4, whereas at Stations 5 to 9 it was between 60 and 90% saturation (Figure 7). With complete mixing in the lake, oxygen should have been near saturation throughout the lake, at least in the top 8 m. The topography of the area was probably a contributing

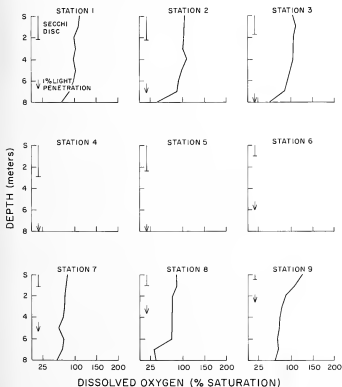


FIG. 5—Percent saturation, Secchi disc and 1% light penetration profiles during October 1971.

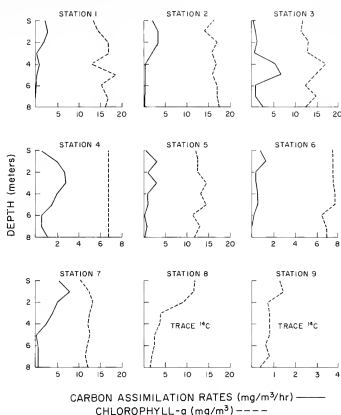


FIG. 6—Vertical carbon assimilation rates and chlorophyll-a concentration profiles during January 1972. Note the differences in scale on the x-axes.

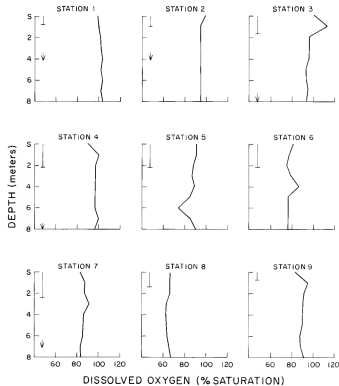


FIG. 7—Percent saturation, Secchi disc and 1% light penetration profiles during January 1972. See Fig. 5 for symbols.

factor to the sub-saturation of dissolved oxygen in the Roanoke River Arm. Much of the Roanoke River Arm lies in the gorge cut by the original stream channel and hence the lake is somewhat protected from wind action by the surrounding mountainous terrain. Although the Roanoke Arm was homeothermous, the mixing rate of the water may have been markedly less than that in the lake proper.

**Spring (May 1972)**—In May, spring warming had occurred and relatively weak stratification was evident throughout the lake (Figure 3). Primary production and chlorophyll-*a* were well distributed throughout the photic zone at the reference stations (1 to 4), and fairly strong surface inhibition was evident (Figure 8). Three definite trends in photosynthetic activity were apparent in the Roanoke River Arm in an upstream progression: a gradual decrease in the depth of photosynthetic activity; an increase in the concentration of chlorophyll-*a*; an increase in the peak rates of primary production except for a slight reversal at Station 8. Peak rates in the Roanoke River Arm were from 3 to 8 times greater than those at the reference stations.

Dissolved oxygen was at or significantly greater than saturation in the photic zone throughout the lake (Figure 9). While saturation values in the reference stations were about 100% or slightly higher, surface values in the upper Roanoke River Arm were well over 125% and the value at Station 9 exceeded 225%. As was evident in October, there was a gradual decrease in lake transparency and depth of light penetration in an upstream direction.

**Summer (July 1972)**—Figure 3 indicates strong

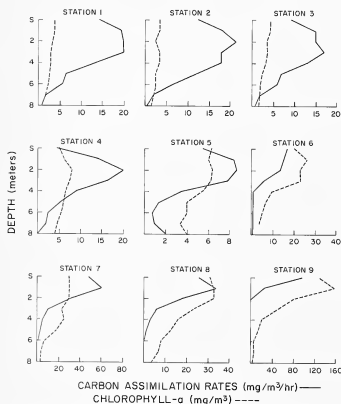


FIG. 8—Vertical carbon assimilation rates and chlorophyll-*a* concentration profiles during May 1972. Note the differences in scale on the x-axes.

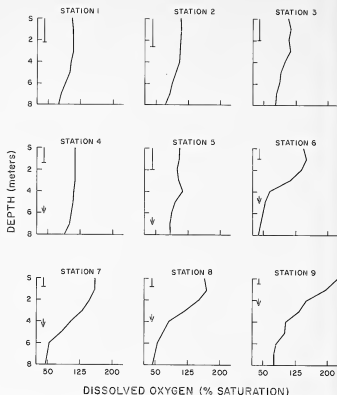


FIG. 9—Percent saturation, Secchi disc and 1% light penetration profiles during May 1972. See Fig. 5 for symbols.

thermal stratification throughout the lake with the well-defined thermocline generally occurring between 4 and 10 m.

Photosynthetic activity, as evidenced by primary production rates and chlorophyll-*a* profiles, was fairly well distributed to a depth at 8 m at Stations 1 to 4 (Figure 10). However, as was observed during previous periods, primary production rate and chlorophyll-*a* curves show that there was a gradual decrease in an upstream direction in the depth at which photosynthesis occurred. Figure 11 shows gradual reduction in the depth of light penetration and lake transparency in an upstream direction in the Roanoke River Arm; a trend that was in close agreement with that of the depth of photosynthetic activity.

Peak rates of primary production in the upstream stations were from 4 to 10 times the values observed in the reference stations (Figure 10). It should also be noted that carbon assimilation was rather severely reduced at Station 9 and was only slightly higher there than at the reference stations. This was probably due to reduced light penetration resulting from high concentrations of algae and/or detrital turbidity in the top meter of water.

Oxygen saturation in surface waters throughout the lake exceeded 100% during the July sampling (Figure 11). As in May, there was a trend of increasing supersaturation in an upstream direction in the Roanoke River Arm in July, with surface values exceeding 200% saturation at the three most upstream stations (7, 8 and 9). The generalized trend of decreasing lake transparency and depth of light penetra-

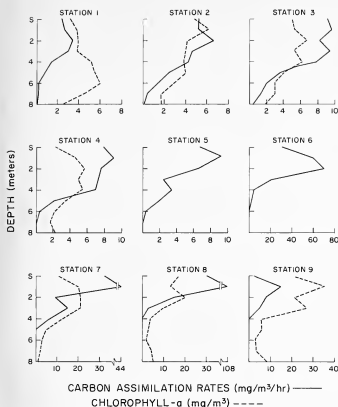


FIG. 10—Vertical carbon assimilation rates and chlorophyll-a concentration profiles during July 1972. Note the differences in scale on the x-axes.

tion observed during previous periods in an upstream direction was quite apparent.

#### Daily Rates of Primary Production Per Square Meter Surface Area

Most recent papers dealing with rates of primary production in lakes have converted the computed hourly rates per unit volume to daily or even annual

rates per square meter of water surface by integration of the carbon assimilation curve. There are obvious flaws in this method but one must follow the convention if one is to compare one's data with those of other workers. Daily estimated rates of carbon assimilated per  $m^2$  surface area at all stations for each experimental period are presented in Table 1.

There was a gradient in daily carbon assimilation rates during October 1971 and July 1972 similar to that observed in the previous sections dealing with peak rates. Highest daily rates measured in October and July in the upstream stations were 10 and 14 times higher than lowest rates at downstream stations. Daily rates in January were low throughout the lake due to low temperatures and especially in the extreme upstream stations due to a combination of temperature and high turbidity. In May, the daily rates per  $m^2$  were approximately equal at the downstream (except Station 4) and upstream stations though the hourly rate peaks were up to 10 times greater at the upstream stations. Referring to Figure 8 the situation can be explained by the shape of the productivity curve. While primary production was well distributed throughout the top 6–7 m at Stations 1 to 3, it was light-limited at Stations 7 to 9 due to high algal biomass and perhaps other turbidity factors.

#### Discussion

Just what constitutes acceptable evidence for the relative trophic states of impounded bodies of water is controversial because the natural variability of lakes and reservoirs makes a standard model difficult, if not impossible, to obtain. However, the various symptoms which have been associated with eutrophication include: relatively high rates of primary production, high concentrations of epilimnetic chlorophyll-a, decreased lake transparency and depth of light penetration, hypolimnetic oxygen depletion and oxygen supersaturation of surface layers (Anderson 1961, Fruh et al. 1966, Sawyer 1966, Stewart and Rolich 1967, Lee 1970 and many others).

Our data show that the Roanoke River Arm of Smith Mountain Lake differed substantially from areas near the dam in the following limnological features: primary production rates, chlorophyll-a concentration, water transparency and depth of light

TABLE 1  
Carbon Assimilation Rates in Smith Mountain Lake  
( $mg/m^2/day$ ).

Station Number	October 1971	January 1972	May 1972	July 1972
1	286	72	1344	168
2	374	110	1470	448
3	333	220	1202	602
4	121	130	504	490
5	462	110	980	460
6	1056	40	418	2352
7	1199	240	1834	1232
8	748	*	1064	1946
9	1221	*	1102	354

\* Trace

FIG. 11—Percent saturation, Secchi disc and 1% light penetration profiles during July 1972. See Fig. 5 for symbols.

penetration, and surface oxygen saturation. Furthermore, the data show that a definable gradient in some or all of these features existed during the fall, spring, and summer periods of the study. Clearly the limnological characteristics of the Roanoke River Arm were those of a nutrient-enriched aquatic system which can probably be classified as eutrophic. The eutrophic nature of the upper reaches of the lake can best be compared to other eutrophic lakes by the daily rates of primary production. While the rates did not reach those reported by Wetzel (1965) in the hypereutrophic Sylvan Lake in Indiana, i.e., >4000 mg/m<sup>2</sup>/day in early spring and late summer, they were close to the 2000 mg/m<sup>2</sup>/day rates observed in eutrophic Clear Lake (California) by Goldman and Wetzel (1963).

There are probably two major factors responsible for the eutrophy of the upper reaches of the Roanoke River Arm of Smith Mountain Lake. The first is the extreme nutrient loading of the Roanoke River by municipal-industrial discharges. Jennings et al. (1970) reported that sewage treatment facilities in the Roanoke metropolitan area discharged some 500,000 lbs of nitrogen (TKN) and 240,000 lbs of phosphorus into the lake's tributaries between January and May 1968.

The second factor is the morphometry of the basin and the surrounding terrain. Center channel depths at Stations 9, 8, 7 and 6 were 8m, 10m, 25m, and 30m, respectively. Depths in the lake proper ranged from 40 to 60 m. Channel widths at Stations 9, 8, 7 and 6 were 96m, 144m, 370m, and 450m, respectively, while widths of the lake proper ranged up to several km. It can be seen that the upper reaches of the Roanoke River Arm are shallower and narrower than the lake proper.

In the area of Stations 6 to 9 the lake shore-line abuts ridges on both sides of the channel that rise up to 60m above normal pool height of the lake. Unless the wind direction coincides with the direction of the channel the ridges provide a wind shadow for the lake surface.

The upper reaches of the Roanoke River Arm seem to be an optimal site for eutrophication. That area of the lake is relatively shallow, narrow and protected from wind and receives nutrient-enriched water from the Roanoke River. Simmons and Neff (1969) considered the lower reaches of the lake to be mesotrophic, and we agree.

It should be mentioned that tertiary sewage treatment facilities are being constructed in the Roanoke

metropolitan area and those facilities should relieve the nutrient loading on the lake.

*Acknowledgments*—This work was funded by a research grant from the Appalachian Power Company.

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H. W. Webb, Jr.

Virginia Division of Mineral Resources  
Box 3667, Charlottesville, Va. 22903

## Topographic Maps for the Commonwealth

There are several types of topographic maps available for areas in Virginia. The most significant are: 1:250,000 scale series, where 1 inch on the map portrays about 4 miles on the ground; and 1:24,000 scale series, where 1 inch portrays about 0.4 mile. The former series depict the "birds-eye" view of large areas with little cultural and natural detail whereas the latter shows a smaller area in great detail. The 1:250,000 series, useful for regional planning, can be obtained either as flat paper maps or as plastic relief maps (the latter has an exaggerated vertical to horizontal scale ratio of 4:1). Base maps of the Commonwealth at the 1:500,000 scale are available in topographic, planimetric (without contours) and shaded relief editions. Special maps are available which depict the Shenandoah National Park, Blue Ridge Parkway, Colonial National Monument and Washington and vicinity.

The preparation of modern topographic maps begins with the photogrammetric plotting of topography, drainage, vegetation, and cultural data which are derived from the stereoscopic inspection of optical models prepared from overlapping aerial photographs. These photos are flown under rigid mapping specifications, usually during late fall or early spring at times of minimal vegetation cover. The horizontal and vertical survey control, classification of cultural features, drainage and vegetation, and identifying names are obtained during an on-the-spot examination of the areas being mapped. Uncertain information from the aerial photographs is also checked at this time. After a multi-editing of the accuracy and clarity of the data shown, the map is printed and made available for sale to the public through U.S. Geological Survey sales offices and map dealers.

Topographic mapping in Virginia began in 1883 at the 1:125,000 scale (1 inch on the map equals about 2 miles on the earth); by 1908 about 75 percent of the Commonwealth had been mapped. The quality of these early reconnaissance-type maps was often dependent upon the map-maker's skill in artistic sketching and woodsmanship. In 1900, with the realization of the need for maps with greater accuracy and topographic detail, a new series was developed at a scale of 1:62,500 (1 map inch equals about 1 mile on the earth). This soon supplanted the 1:125,000 maps, even before Virginia was fully covered by the latter series. In 1909 the Commonwealth, with an expenditure of \$1750, became one of the first states to begin a cooperative mapping program with the U.S. Geological Survey; this program still continues. By

the late 1930's, due to the demand for even greater detail and accuracy, the present program of mapping on the 1:24,000 scale (1 inch on the map equals 2000 feet on the earth) was begun. These maps have been prepared by the U.S. Geological Survey, the U.S. Coast and Geodetic Survey, Tennessee Valley Authority and the U.S. Corps of Engineers. Each of these maps portrays an area of 7.5 minutes of latitude and longitude, about 60 square miles. They have now supplanted the older 1:62,500-scale series.

An accelerated \$9 million cooperative mapping program between the Commonwealth of Virginia and the U.S. Geological Survey was started by the Virginia Division of Mineral Resources in 1962 to complete the coverage of the 1:24,000-scale series. By November 1972 all of the 805 maps needed to depict the State became available in modern form. Virginia became the tenth state then to be completely covered at this scale of mapping.

With the recognition that maps in urban areas quickly become outdated, a continuing program of revision was begun in 1968. Changes are determined from the inspection of aerial photographs within the program, and these new data are shown on the maps in purple. In addition to the usual topographic information these photorevised maps now depict the dimension of time, which is useful for planning and urban development. Maps of most independent cities are now available in this form. Beginning in Spring 1972 a new method of determining which maps needed to be revised was initiated with high-altitude quad-centered photography for the northern fifth of the Commonwealth. The amount of change determined from the photographs, combined with State and Federal needs, will determine which maps need to be revised. In this way every part of the Commonwealth will be examined photographically once every five years. Maps of growth areas will be no more than five years out of date.

Names of places, water features, landforms and religious institutions from the 1:24,000-scale series are available in Information Circular 20, *Geographic and Cultural Names in Virginia* (obtainable from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, Va. 22903, for \$2.86 including 4% sales tax to addresses in Virginia).

A pilot program is in progress to prepare the following products from the 1:24,000-scale maps: orthophotoquads, slope maps, orthophoto maps and county maps. The orthophotoquads are photographic depictions of the 1:24,000-scale maps on which scale measurements can be made. The best information on the land surface can be obtained by using orthophotoquads with the corresponding

topographic maps, since the former depict land-use, fence-lines and type and extent of woodland, while the latter show relief and name features. Eleven orthophotoquads are available: Charlottesville, Front Royal, Fredericksburg, Gainesville, Leesburg, Luray, Sterling, Winchester and others. Fifty-nine others are being prepared for selected quadrangles in central and eastern Virginia.

Slope maps, on which the inclination of the land is portrayed by percent-slope categories depicted on a topographic base, will be available for ten quadrangles across the state. Orthophoto maps, which are multicolored photographic images with which information from the topographic maps has been combined, are being made for the Dismal Swamp and Wachapreague areas. Compositing topographic information from the 1:24,000-scale maps prepared as a country map is available for Stafford County at a scale of 1:50,000. Similar maps are in progress for New Kent and Warren counties.

As a by-product of the cooperative mapping program, aerial photographs are available for most of the Commonwealth. Stereoscopic examination of overlapping prints shows the landscape in three dimensions. From aerial photographs such features as land use, the type and extent of woodland, fence and field lines, and the shapes of temporary bodies of water can be interpreted.

Beginning in the Spring of 1972 high altitude quad-centered mapping photography is to be flown for each sector of Virginia once every five years. Photos are now available for northern, eastern and central Virginia. Only one of these overlapping 9-inch by 9-inch photographs at a scale of about 1:72,000 is needed to depict the area of a 1:24,000-scale map; the center of the photo is the center of the corresponding topographic map. A 3-times enlargement is about the same scale as the map. For that part of the State not covered by high-altitude photos, coverage for a 7.5-minute quadrangle consists of from 15 to 20 photographs at about 1:24,000 scale. Mapping photographs can be ordered from the Eastern Mapping Center, U.S. Geological Survey, National

Center, Reston, Va. 22092. Information on availability of other aerial photographs and photomosaics can be obtained from the National Cartographic Information Center, U.S. Geological Survey, Reston, Va. 22092.

The following factors should be considered in using maps. Information is current only to the date of the map. A comparison of new maps with old maps may show that place names have changed or been deleted, or that roads have been renumbered or relocated. Because the paper on which maps are printed is affected by changes in temperature or humidity, the accuracy of scale measurements may differ across the face of the map; stable-base mylar copies can be obtained from the Eastern Mapping Center. Accuracy of locating points on topographic maps is prescribed under National Map Accuracy Standards. For maps of 1:24,000 scale, 90 percent of well-defined points are within 40 feet of their horizontal position and within one-half contour interval of their vertical position. If a map is enlarged, scale measurements may be in error due to the location of certain points, which at the original scale were shifted from their true position to obtain clearance from other adjacent graphic symbols or were enlarged in size so they could be shown on the map; roads are depicted with a minimal width of 40 feet. Trees and cleared areas in woodland less than certain minimal dimensions are not shown.

All 805 quadrangle maps of the 1:24,000 scale series needed to depict the Commonwealth are available. Each quadrangle costs 75 cents from the Distribution Section, Geological Survey, 1200 South Eads Street, Arlington, Va. 22202. A free Index indicating locations and names of these 1:24,000 scale maps can be obtained from the Distribution Section. This index includes information on other types of maps, addresses of firms in Virginia selling maps, and a listing of map reference libraries. Information on the status of map revision and the Virginia mapping program can be obtained from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, Va. 22903. The Division also has a map sales office.

## News and Notes

### Research Awards, 1974-1975

The following people have received Research Awards from the Academy:

Dr. Joseph P. Chinnici, Department of Biology, VCU

Dr. Elizabeth B. Conant, Department of Biology, Mary Baldwin College

Drs. Peter Dalby, Klaus D. Elgert and Joseph O. Falkinham, Department of Biology, VPI & SU

Persons interested in research awards should contact the chairman of the Research Committee, Dr. J. Doyle Smith, Department of Chemistry and Pharmaceutical Chemistry, MCV, Box 666, Richmond, Va. 23219.

### Philip Morris Science Symposium

The Second Philip Morris Science Symposium will be held at the Philip Morris Research Center in Richmond on October 30, 1975. The theme of the Symposium will be "The Recent Chemistry of Natural Products, including Tobacco", and the speakers will include Dr. Melvin Calvin, University of California at Berkeley; Dr. A. Ian Scott, Yale University; Dr. Richard E. Schultes, Harvard University; Dr. Thomas S. Osden, The Philip Morris Research Center; and Sir Derek H. R. Barton, Imperial College of Science and Technology, London. Lord Todd, Master of Christ's College, Cambridge, will preside. For further information contact Nicholas J. Fina, The Philip Morris Research Center, P. O. Box 26583, Richmond, Va. 23261.

### Mountain Lake Biological Station, 1975

The University of Virginia announces eight graduate courses in biology to be offered at the Mountain Lake Biological Station this summer. They are as follows:

First Term: June 12 through July 15

Taxonomy of Flowering Plants, Dr. Lytton J. Musselman, Old Dominion University  
Plant Ecology, Dr. Gary L. Miller, Eisenhower College

Entomology, Dr. George W. Byers, University of Kansas

Ornithology, Dr. David W. Johnston, University of Florida

Second Term: July 17 through August 19

Plant Biosystematics, Dr. C. Ritchie Bell, University of North Carolina

Biology of Fungi, Dr. Meredith Blackwell, University of Florida

Invertebrate Ecology, Dr. George E. Stanton, Columbus College

Vertebrate Ecology, Dr. Charles G. Yarbrough, Campbell College

Four fellowships of \$150 each are to be awarded. Two North Carolina Botanical Garden fellowships

will be awarded to superior students with preference to those who have previously held work scholarships at the Station. Two additional awards will be made from the Mountain Lake Fellowship Fund established by friends of Mountain Lake. Contributions are invited for additional support for this fund. The fellowships may not be held concurrently with any other stipend from the Station. The recipients of these awards are chosen by the Research and Awards Committee of the Department of Biology. Application for awards should be sent to the Director, Mountain Lake Biological Station, Gilmer Hall, University of Virginia, Charlottesville, Virginia 22903.

### Association of Official Analytical Chemists, Annual Meeting, 1975

The 89th Annual Meeting of the AOAC will be held at the Marriott Hotel, Twin Bldgs, Washington, D.C., October 13-16, 1975. There will be papers and symposia on methods of analysis for materials and products important to health and agriculture. For further information, contact L. G. Enslinger, Executive Secretary, AOAC, Box 540, Benjamin Franklin Station, Washington, D.C. 20044.

### Elton Cromwell Cocke 1901-1975

Elton Cromwell Cocke was born at Rockville, Hanover County, Virginia, January 31, 1901. The son of Merton Ashley Cocke and Robertine (Toler) Cocke, he was a direct descendant of Colonel Richard Cocke who came to Virginia from England prior to 1628. Following early education in the local public schools Elton entered the University of Richmond. After several terms there he withdrew to teach in the public schools for a period, after which he entered the University of Virginia. At the University he obtained the B.S. degree in 1927, the M.S. in 1928, and the Ph.D. degree in 1931. All degrees were in Biology. From June 1928 to August 1929 he served as Assistant Professor of Biology at Radford State Teachers College.

After receiving the doctorate, Dr. Cocke remained on the teaching staff of the University of Virginia until 1938. When William Louis Poteat, once President and for many years Chairman of Biology at Wake Forest, died in 1938 Professor Cocke accepted appointment to the vacancy created on the Biology faculty at Wake Forest College. He continued to teach at Wake Forest until his retirement in 1971, and remained active in the department of Biology until his death, January 23, 1975.

In his 33 years of active service at Wake Forest, Elton Cocke participated in the growth of the school from a good regional college to a national university. He saw the Biology Department grow from two full time members to a full time faculty of 16, plus 3 adjunct professors. Much of this growth occurred dur-

ing his tenure as department chairman. He taught in a period of exciting and revolutionary change in biology itself, and was an active and concerned participant in all these changes. He was deeply devoted to Wake Forest and served, at one time or another, on practically all of its major committees. He went to Wake Forest during the depression of the 1930's and taught during the Second World War often carrying teaching loads and responsibilities that seem almost impossible in the perspective of more recent conditions.

Elton Cocke always thought of himself as a teacher, an area in which he was very effective. He was always thoroughly prepared in his courses, which were known for their rigor. He demanded much of his students, but because of his enthusiasm and total fairness, thousands of students who passed through his courses left with a love and understanding of biology as well as of broad and humane learning. His teaching excellence was attested to when he received the 1970 Meritorious Teaching Award of the Association of Southeastern Biologists. Dr. Cocke kept a record of all students whom he taught and the list contained over 12,000 names, almost 10,000 of them Wake Forest students, the others in his classes during seven years at the University of Virginia and a short period at Radford College. It was the expressed opinions and praise of hundreds of these former students which were responsible for his 1970 recognition as a truly outstanding teacher.

While primarily a teacher, and one who also devoted considerable time most effectively to administrative duties as well, Dr. Cocke never lost interest in original research and always 'made' time in which to continue his studies and writing. Early studies dealt with pollen—fossil pollens, particularly of the Dismal Swamp, as well as atomospheric pollen surveys. His later interests were chiefly in the areas of either Phycology or Dendrology. His authoritative book "The Myxophyceae of North Carolina" appeared in 1967, while his "Trees and Shrubs of North Carolina" was written after retirement and was published in 1974. An earlier, 1943, work "Outline of Lectures in General Biology" went through six editions. Two of his

publications record in depth the development of the department with which much of his professional life was so closely intertwined. "A History of the Wake Forest University Biology Department" appeared in 1969, while "The First Hundred: A Study of the Graduate Program of the Department of Biology of Wake Forest University, 1889-1974" came from the press in mid-January 1975.

Primarily a botanist, Professor Cocke was trained in the broad tradition of natural history and resisted compartmentation. Equally at home with botanical or zoological material, in his classroom he insisted on the broader synthesis rather than any narrow view. In searching out good young teachers for the department in many cases he sacrificed his own time and gave up courses he had taught for a long time in order that the department might attract and retain an able staff.

Professor Cocke's industry, attainments and results are doubly emphasized by the fact that while severely crippled in his youth, he refused to let this handicap him. His indomitable courage served as an example to his students, colleagues and friends.

Throughout his professional career Elton Cocke was active in the major specialized and general, national and regional, professional organizations in his field. He was a past president of the North Carolina Academy of Science. He was a member of the Virginia Academy of Science for over 46 years, from near the time of its inception, and regularly attended and participated in its annual meetings. At the 1973, Fiftieth Anniversary, meeting in Williamsburg he presented original papers before the sections both of Biology and of Botany, in addition to serving effectively on a panel of five persons leading a symposium-type discussion on "Early Botany and Botanists in Virginia." In the passing of Elton Cocke the Academy has lost one of its ablest, most loyal, and most enthusiastic members. He is survived by his wife, Virginia Webb Cocke, whom he had married while they were students at the University of Virginia; two daughters, Mrs. Virginia Cocke Bloch, and Mrs. Mary Gilmer Cocke Van Poole; a number of grandchildren; and a brother.

Walter S. Flory



# Advice to Authors

The Virginia Journal of Science welcomes for consideration original articles of technical or general interest in all phases of mathematics, the biological, physical and engineering sciences. Submission of an article implies that the article has not been published elsewhere while under consideration by the Journal.

All articles should be typewritten, double-spaced throughout, on good bond paper ( $8\frac{1}{2} \times 11$  inches) and should be submitted to the Editor in triplicate. Margins should be not less than  $1\frac{1}{4}$  inches on any border. The following items should be on individual pages separate from the text: title, running title, authors and addresses, abstract (followed by text), acknowledgments, literature cited, legends, tables, and figures. Technical abbreviations should follow consistent standard practices. All pages (including illustrations) should be numbered in pencil in the upper right hand corner.

Illustrations should be prepared in a form suitable for the printer, with attention to the fact that a reduction in size may be necessary. Photo-copies may be submitted with the manuscript. Do not write on the back of the original illustrations; an identifying label with the author's name should be affixed to the sheet at the bottom of the back.

Technical articles should have an informative abstract giving the essential methods and conclusions.

For review articles or those in some fields (e.g., history) an abstract may not be appropriate.

References in the text should follow the name-and-year format, for example: Rosenzweig and MacArthur (1963) or (Rosenzweig and MacArthur 1963). References in the section of Literature Cited (which should be so titled) should follow the Council of Biological Editors Style Manual, for example:

Rosenzweig, M., and R. MacArthur. 1963. Graphical representation and stability conditions of predator-prey interactions. *Am. Natur.* 97:209-223.

Harmon, H. H. 1960. Modern factor analysis. University of Chicago Press, Chicago.

Colbert, Edwin H. 1958. Morphology and behavior. Pages 27-47 in Anne Roe and George Gaylord Simpson, eds. *Behavior and evolution*. Yale University Press, New Haven.

Abbreviations of journal titles can be found in the 4th edition of the World List of Scientific Publications (Butterworth, Inc., Washington, D. C. 1963) and supplements. References should be checked carefully. If in doubt give the complete title of the journal.

Please note that the format of references is a change from past practice in the Journal.

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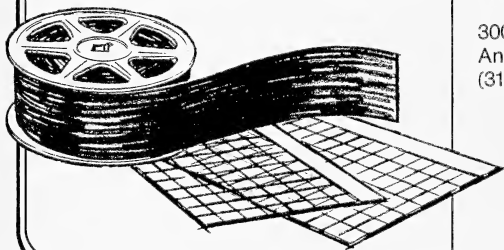
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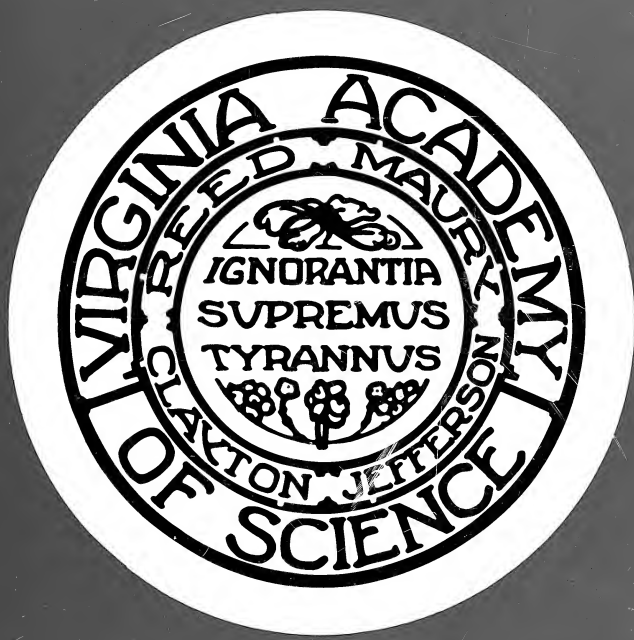




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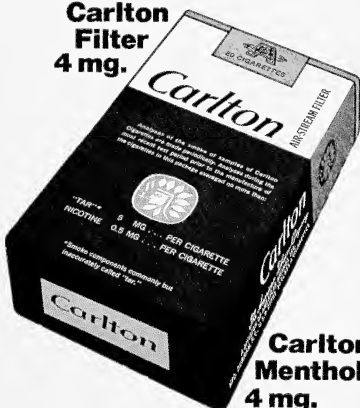
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Published quarterly by The Virginia Academy of Science, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Second-class postage paid at Richmond, Virginia.

Manuscripts for publication (other than section abstracts) should be sent to the Editor, Dr. David A. West, Department of Biology, V.P.I. and S.U., Blacksburg, Virginia 24061. Proof, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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# VIRGINIA ACADEMY OF SCIENCE

## FIFTY-THIRD ANNUAL MEETING, HARRISONBURG

### MAY 6-9, 1975

#### SUMMARY OF ACADEMY CONFERENCE AND ACADEMY ASSEMBLY

#### AND NOTES FROM COUNCIL MEETING

May 8, 1975

The Academy Conference of the Virginia Academy of Science was held at Madison College, Harrisonburg, Virginia, on May 8, 1975. President Wisman called the Conference to order at 11:35 a.m. About 70 members were in attendance.

Mr. J. W. Midyette, Jr., Chairman of the Constitution and Bylaws Committee, submitted the following constitutional changes for adoption:

1. Amend Article III, Section 6, Standing Committee as follows:

- a. Delete in line 6 after, "the Nominating Committee" the clause "the Science Talent Search Committee."

2. Amend Article VII, Section 1 as follows:

- Insert "Visiting Scientists Program Director" in 3rd sentence. Amended sentence to read "In addition to the foregoing, the Chairman of the Standing Committee, the Editor of the Virginia Journal of Science, and Visiting Scientists Program Director shall be members of Council."

These proposed changes had been approved by Council and distributed to the membership in accordance with the Constitution. Motions to adopt the two constitutional changes were seconded and approved unanimously. Mr. Midyette called attention to proposed Bylaw changes which had been distributed to the membership and which will be acted on by Council on May 9, 1975.

Dr. D. Rae Carpenter, Jr., Chairman of the Finance and Endowment Committee distributed copies of the financial report of the Academy noting two changes: 1) the inclusion of the income from the Trust Fund as a line item under Receipts, and 2) the addition of Committees, principally the Research and Flora Committees, as a line item under Disbursements. A total of \$35,116 was disbursed in 1974 and a \$34,245 budget has been approved for 1975. General Fund Assets at the end of 1974 remained at the level of about one year expenses as has been the policy of Council. Dr. Carpenter called attention to the membership being at an all-time low at the end of 1974, and expressed special concern that business memberships may decrease.

Mr. Addison D. Campbell, Chairman of the Membership Committee described the new

membership brochure. Five thousand copies have been printed with approximately 2500 distributed along with application forms to representatives at colleges and universities and to high school science and mathematics teachers. Ninety new members have joined since January 1, 1975, bringing the total membership to 1623. Unfortunately, 279 of last year's members have not yet renewed their membership and may have to be dropped from the rolls resulting in a net loss. Mr. Campbell urged each member to share in the responsibility of promoting new memberships and securing renewals of former members. The Committee does not have representatives at some institutions and would like volunteers.

Dr. John L. Hess was introduced as the new Director of the Virginia Junior Academy of Science. Dr. Lee S. Anthony, retiring Director, reported that registration at the VJAS meeting was about the same as last year, approximately 500 including 350 students. The enthusiasm and competition has been greater than ever and the VJAS program continues to offer a very rewarding and valuable experience to the science-oriented high school student. Of the more than 300 papers submitted, 159 were selected for presentation at the Annual Meeting. The new VJAS officers are: President, Bruce R. Marton, Wakefield Senior High School, Arlington County; Vice-President, Ursula E. Schwes, Washington-Lee High School, Arlington County; and Secretary, Vickie L. Shelton, The Collegiate Schools, Richmond. An excellent slide-lecture was presented to the VJAS on May 7 by Ms. Emily Ford, Hollins College, on "Life in the Serengeti."

President Wisman on behalf of the Academy recognized with appreciation the very fine job done by Dr. Anthony as Director of VJAS for the past three years.

Dr. Edward F. Turner, Chairman of the Nominating Committee, offered in nomination the following slate of officers for the Academy for 1975-76:

President: Dr. Arthur W. Burke, Jr., MCV-VCU  
 President-elect: Dr. W. Allan Powell, University of Richmond

Secretary: Dr. Ralph A. Lowry, University of Virginia

Treasurer: Dr. Dale V. Ulrich, Bridgewater College

Motions that nominations be closed and that the

slate of officers recommended by the Nominating Committee be accepted were seconded and passed by unanimous votes.

The Conference joined in an expression of appreciation and thanks to Dr. Wilbur T. Harnsberger and the Local Committee on Arrangements at Madison College for an excellent Annual Meeting and a job well done.

Dr. Dorothy Bliss, Chairman of Ad Hoc Committee on Nation's Bicentennial reported on the Committee's plans for a program at the 1976 Annual Meeting to celebrate the Nation's Bicentennial. These commemorative activities will include three invitational papers to be published in the Virginia Journal of Science: "The Development of Technology and Industry in Virginia," "The History of Biological Sciences in Virginia," and "The History of the Physical Sciences in Virginia." The Academy will also sponsor a competitive research paper on some historical aspect of science or scientist in Virginia for secondary school students and a special Wednesday evening program highlighting the theme of colonial science.

Executive Secretary-Treasurer Bruner reported a letter received from Governor Mills E. Godwin requesting the Academy's help and cooperation in a State-wide program to clean up and beautify Virginia's public places, private homes, businesses, and neighborhoods for the period of the Bicentennial and beyond. This matter will be referred to the Executive Committee for recommendations and action.

President Wisman announced that next year's Annual Meeting will be held at George Mason University on the dates of May 11-14, 1976.

Dr. Rae Carpenter, Chairman of the Board of Trustees of the Science Museum of Virginia, introduced the Director of the Museum, Paul Knappenberger, who gave a brief report on the status of the Museum. In 1967 the Academy prepared and sent to the Governor a resolution asking that a Study Commission be created. That Study Commission resulted in a nine member Board of Trustees being formed in 1971. At the present time the Board is ready with working drawings to construct the first facility. This facility, to be located in the Richmond area, is estimated to cost \$8 million of which \$1.5 million has been pledged from non-State funds. Most of the remaining funds needed will hopefully be appropriated from the State's General Fund during the next session of the General Assembly. Both Dr. Carpenter and Dr. Knappenberger urged the continued support of the Academy in securing these funds and suggested that the most effective way to help is for individual Academy members to write to the Chairman of the Senate Finance Committee, the Chairman of the House Appropriations Committee, the Governor, or to any member of the above committees known to them. The Museum has already started several programs including a mobile unit used at schools and public places. Planning has begun on a Western Division facility in the Roanoke area where the Science Museum Association of Roanoke Valley has raised over \$65,000 and hired an architect.

Written reports were filed by the following committees:

Finance and Endowment Committee (financial report)  
Junior Academy of Science Committee  
Long Range Planning Committee  
Publications Committee  
Trust Committee  
Virginia Flora Committee  
Ad Hoc Committee on Industry Relations  
Ad Hoc Committee to Plan Science Advisory System  
Ad Hoc Committee for Science Museum of Virginia  
Ad Hoc Committee on the Nation's Bicentennial  
Ad Hoc Committee for State Science Teachers Conference  
Visiting Scientists Program  
There being no further business, the Academy Conference was adjourned at 12:20 p.m.  
Respectfully recorded,  
Ralph A. Lowry  
Secretary

### The Academy Assembly

May 8, 1975

Following the Annual Banquet, the Virginia Academy of Science Assembly was convened at 8:30 p.m. on May 8, 1975, in Chandler Hall, Madison College, Harrisonburg, Virginia, with President Wisman presiding. Dr. Ronald E. Carrier, President of Madison College opened the Assembly with a few welcoming remarks.

Presentation of awards were as follows:  
Honorary Life Membership Award:

A. B. Massey, VPI&SU

Academy Fellows:

Franklin F. Flint, Randolph-Macon Woman's College  
Horton H. Hobbs, Jr., U. S. National Museum, Washington, D. C.  
Michael Kosztarab, VPI&SU  
Vera B. Remsburg, Herndon High School  
William E. Trout, Jr., University of Richmond  
W. Peter Trower, VPI&SU  
Edward F. Turner, Jr., Washington and Lee University

Ivey F. Lewis Distinguished Service Award:

Edward S. Harlow

J. Shelton Horsley Research Award:

Roddy V. Amenta, Madison College, for the paper entitled  
"Multiple Deformation and Metamorphism from Structural Analysis in Eastern Pennsylvanian Piedmont"

Dr. William J. Darby, President of the Nutrition Foundation, New York, delivered the Sidney S.

Negus Memorial Lecture: "Role of Science and Technology in Meeting World Food Needs."

New Academy Officers were installed:

President: Dr. Arthur W. Burke, Jr., MCV-VCU

President-elect: Dr. W. Allan Powell, University of Richmond

Secretary: Dr. Ralph A. Lowry, University of Virginia

Treasurer: Dr. Dale V. Ulrich, Bridgewater College

Respectfully recorded,

Ralph A. Lowry

Secretary

### Council Meeting, May 9, 1975

Mr. J. W. Midyette, Jr., Chairman of the Constitution and Bylaws Committee submitted the following bylaws changes:

1. Amend Article I; Types of Membership and Dues  
Section 5: Delete current wording and substitute following:

Honorary life members shall consist of persons elected by the Council for long and distinguished service to science. They shall have all the rights and privileges of regular members and shall be exempt from dues. Previous active membership in this organization shall not be an eligibility requirement.

2. Amend Article III; Duties of Standing Committees as follows:

- a. Add to Section 3, The Junior Academy of Science Committee shall:

- (13) Canvass colleges and universities for scholarships available to Science Talent Search Finalists.

- (14) Forward list of available scholarships to all high school sponsors that have re-

quested applications for the Westinghouse Science Talent Search.

- (15) Secure list of Virginia contestants from Science Clubs of America and establish a committee to select best 45 papers.

- (16) Set up procedures for selecting the top 15 students and declare and announce them to be State Winners in the Virginia Science Talent Search, and all other contenders as runners-up.

- (17) Send names of winners and runners-up to colleges and universities in Virginia.

- b. Delete Section 11 of Article III.

- c. Re-number Section 12 as Section 11, Section 13 as Section 12.

3. Amend Article VI, as follows:

- a. Delete (11) Science Teachers and add in lieu of (11) Education.

- b. Add (15) Environmental Science.

4. Amend Article IX: Executive Secretary-Treasurer as follows:

Section 4. Delete present wording and substitute the following:

The incumbent of this position shall attend all Council and Executive Committee Meetings and may participate in all deliberations as circumstances dictate, but, shall not have a vote in either body.

5. Add; Article X: Visiting Scientists Program Director.

Section 1. The position of Visiting Scientists Program Director is hereby established for the purpose of implementing a Visiting Scientists Program in cooperation with the State Board of Education.

Section 2. The Executive Committee upon recommendation of the President shall select a qualified person for this position and approve guidelines for the conduct of the program.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

The changes were adopted by Council.

Mr. Stanley Ragone was elected to the Trust Committee for a three-year term.

## Abstracts of Papers

# Section of Agricultural Sciences

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

HEIGHT OF STUBBLE CUT AND STRAW MULCH CONCENTRATION EFFECTS ON YIELD AND CERTAIN AGRONOMIC CHARACTERISTICS OF NO-TILLAGE PLANTED SOYBEANS. M. W. Alexander, H. M. Camper and C. Hovetmale\*, Tidewater Research and Continuing Education Center, Suffolk, Va. 23437; Eastern Virginia Research Station, Warsaw, Va. 22572 and Department of Agronomy, Blacksburg, Va. 24061.

The relationship of three straw mulch concentrations and three stubble heights of small grain to certain agronomic characteristics of soybeans in a no-tillage regime were studied at two locations. The straw mulch associated with a given stubble height is designated X, twice this amount 2X and 0 all removed. Stubble cuts were low 10.2cm, medium 20.3cm and high 35.6cm at Warsaw and 40.6cm at Suffolk. Difficulty was experienced in obtaining seed to soil contact with 2X mulch resulting in reduced plant emergence some years. At Warsaw, 0 and X mulch gave a higher seed yield than the 2X level; however, at Suffolk, there was only a trend toward high yield with X mulch. Highest yield at Suffolk was obtained with a medium height stubble and a trend toward this was noted at Warsaw.

EGG SHELL COLOR IN JAPANESE QUAIL. W. L. Beane, Dept. of Poultry Science, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

The shell color of the deeply pigmented quail egg is due to the secretion of porphyrins by the uterine epithelium. This pigment is deposited mainly on the surface, or cuticle portion, of the shell in splotches of varying sizes, shapes and thickness during the three to five hours immediately prior to oviposition.

Female quail tend to lay eggs that are individually characteristic with respect to size, shape and color. Since no efficient trapnest system currently exists for use with quail, the utilization of these traits may permit identification of eggs with reasonable accuracy from multi-female pens. Females producing eggs having distinctly different color patterns could be combined into groups of three or four per pen with a minimal loss of egg identification. Occasionally, a female quail will lay an egg that differs from her normal type, however, the chances are minimal that two or more birds in a given pen will lay non-characteristic eggs on any one day. In such rare cases, positive identification is not possible and the egg can not be used for obtaining data on the individual bird in question. Nevertheless, loss of identification of eggs in small multi-female pens should be minimal if the females are properly selected for a given pen.

THE BIOLOGY AND DISTRIBUTION OF THE NORTHERN CORN ROOTWORM (*DIABROTICA LONGICORNIS*) - A NEW PEST IN VIRGINIA. W. A. Allen, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

*Diabrotica longicornis* (Say) has been spreading south and east in the USA. The first collection in Virginia occurred in Floyd County during 1971. It subsequently has been found in Montgomery, Wythe and Culpeper counties. The insect is monophagous and univoltine. Adults are approx. 4.7 mm long and 2.1 mm wide. The head and antenna are light brown; the thorax is bright green; and the elytra and legs are yellowish-green. Adults may be found feeding on corn silk and the pollen of various weeds during August and early September. Adults oviposit in soil near corn plants during early fall. Eggs in other states have been recovered at depths up to 9 inches? In Spring eggs hatch and larvae migrate to corn seedlings to feed upon roots. Excessive larval feeding causes stunted plants, reduced yields and lodging. Heavy adult feeding results in poor pollination. Larvae tunnel corn roots and may range to approximately 10 mm in length; the body is white; the head is tan. Pupae are white and are found in soil near the roots during late July. Crop rotation is an effective non-chemical control measure. In continuous corn insecticides give reliable control.

\*Patel, K. K. and J. W. Apple. 1967. Ecological studies on the eggs of the northern corn rootworm. *J. Econ. Entomol.* 60: 496-500.

POLLUTION OF A SHALLOW AQUIFER FROM SWINE WASTE LAGOONS. E. R. Collins\*, T. G. Cirovala\*, D. C. Martens, D. L. Hallock, E. T. Kornegoy, and H. R. Thomas. Depts. of Agricultural Engineering, Agronomy, and Animal Science, VPI&SU, Blacksburg, Va. 24061.

Three swine waste lagoons in the Coastal Plain of Virginia were studied to determine their effects on ground water quality in high water table, poorly-drained soils. Test wells were established at 3m, 4.6m, and 6m depths and at 3m, 15m, and 30m distances around lagoons. Levels of  $\text{NH}_4$ ,  $\text{Cl}^-$ , and fecal coliform bacteria generally decreased with increasing distance from lagoons and increasing well depth. Data collected for 16 mos. on one lagoon indicated no significant effects on ground water quality beyond 3m from the lagoon edge. Only 5 mos. of data were reported for two other lagoons, but a similar trend was observed. The study is continuing.

THE WHITE-PINE WEEVIL, *PISSODES STROBI* (PECK), IN SOUTH-WESTERN VIRGINIA - VOLUME LOSSES TO WHITE PINE COMPARED WITH LOSSES IN THE NORTHEAST. P. J. Egan, Jr.,\* and H. J. Heikkinen,\* Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061.

Thirteen white pine plots, ranging from 15-26 years in age and one-tenth acre in size, were sampled in six counties of southwestern Virginia.

Most of the weevil attacks occurred when the trees were between 5 to 12 years old. The incidence of attack by the white-pine weevil ranged from 3.5 to 98.6 percent and averaged 40 percent of the trees per plot. The incidence of forking was found to be 4.1 percent of the weeviled trees.

Three distinct lateral branch to terminal shoot ratios were observed, one for the years 5-9, 10-19 and 20-26 of the trees' growth. If the terminal shoot was killed when the tree was in one of these age groups, a loss in volume due to a weevil attack would be 1.9, 1.6 and 1.0 percent respectively. Height loss due to a weevil attack is represented by the difference in length of the killed terminal shoot and the lateral branch that replaces it.

Volume loss to white pine in Virginia due to white-pine weevil attacks is not as great as in the Northeast. One could expect to find approximately 100-150 trees per acre that had either been weeviled once or not at all in the first log.

GEOGRAPHICAL VARIATION IN NEEDLES AND CONES OF CHAMAECYPARIS THYOIDES. P. P. Feyer\*, S. J. Desjardins\*. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Collections were made of Atlantic white cedar cones and foliage from five trees within each of eleven locations from Florida to Maine. Measurements were made of cone diameter, cone scale number, leaf length and branchlet width. Analysis of measured variables demonstrated significant among location differences for all except branchlet width. Graphical analysis of mean values plotted over latitude of origin illustrated a clinal pattern of variation from Florida to New Jersey. Patterns of clinal variation changed dramatically north of New Jersey indicating that quaternary glaciation may have been a factor responsible for intraspecific variation in the northern portion of the species range.

THE EFFECTS OF NEMATODE INFECTION ON STEROL CONTENT IN SOY-BEAN SHOOTS. J. A. Fox, D. M. Orcutt, L. H. Aung, and Sue A. Meredith. V.P.I. & S.U., Blacksburg, Va. 24061.

Comparisons were made of sterol composition in 15-day-old shoots of two soybean varieties, Lee (L) and Pickett (P), susceptible and resistant, respectively, to *Heterodera glycines* (HG). Chloroform-methanol (v/v) extracts of the shoots were analyzed for free sterols (FS), acid-hydrolyzable sterols (AS), and base-hydrolyzable sterols (BS). The total sterol content (mg/g dry matter of tissue) of all fractions increased except the BS fraction of P as a result of infection with HG (approximately 100 nematodes/plant). In the FS fraction, cholesterol, campesterol, stigmasterol, and  $\beta$ -sitosterol increased in P due to infection; in L, campesterol and  $\beta$ -sitosterol increased but cholesterol and stigmasterol decreased. In the AS fraction, there was little or no change in the four sterols of P due to infection, but in L they all increased. In the BS fraction, cholesterol, campesterol and stigmasterol of L increased due to infection, but  $\beta$ -sitosterol decreased. In P stigmasterol and  $\beta$ -sitosterol increased, cholesterol decreased but no change was noted in campesterol due to infection. These data indicate that root infection by the HG nematode causes an endogenous change in sterol metabolism of the soybean shoot resulting in a general increase in sterol content.

(Aided by CSRS Grant 316-15-69)

EVALUATION OF METHODS MEASURING ROOT EXUDATION: IN SITU VS. MODEL SYSTEMS. M. G. Hale and G. J. Griffin. Dept. of Plant Pathology and Physiology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

Root exudation into the rhizosphere can be measured in a variety of ways both in situ and in model systems. In situ methods may measure the net ecological effects when bioassays are used. Effects on specific microbial populations give reasonable estimates of ecological events in nature. For example, injury to peanut fruits results in increased spore germination of *Aspergillus flavus* and increased colonization of peanut fruits. Injury also results in increased exudation of sugars and amino-N under axenic conditions. Results are not always as easily interpreted. In a mixed population of rhizosphere microorganisms, some may inhibit others and the relationship between exudates and microbial populations becomes complex. It is difficult also to extract and identify root exudates from soil on two counts: microorganisms alter them or reduce concentrations below detectable amounts; and strong solvents are often used which remove compounds from cells. Supplemental studies using axenic models may be subject to artifacts. Re-infection procedures to establish model systems have not been successful. Identification of exudate compounds and factors affecting their exudation have given useful information which can be related to effects on specific organism-root interactions.

THE THEORETICAL BASIS FOR A PHYSIOLOGICAL UNDERSTANDING OF ROOT EXUDATION. M. G. Hale and L. D. Moore. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Root exudation plays an important role in the ecology of the rhizosphere with respect to populations of microorganisms and the functioning of the root. Whereas much emphasis has been placed on the role of exudates as carbon and nitrogen sources for microorganisms in the rhizosphere or as sources of attractants or repellants for plant pests, the role of root exudates in plant health and vigor has been largely overlooked. The processes of growth and development, the formation of soluble pools within the root, and the translocation of photosynthates to roots are affected by a number of environmental factors which also affect the quantities of exudates and the spectrum of compounds exuded. Secretory processes as well as electrochemical potential gradients are responsible for exudation through the symplast and/or apoplast. In a sense, the soil can serve as a sink for metabolites from the root. The organisms that utilize the exudates may be beneficial to the plant or detrimental to its health and vigor. In either case, they are a more or less integral part of the absorbing system.

EFFECT OF SOCIAL STRESS AND INHERITED PLASMA CORTICOSTERONE LEVELS IN CHICKENS ON POPULATIONS OF THE NORTHERN FOWL MITE, *Robert D. Hall*.\* Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Cockerels previously selected for a low level of plasma corticosterone and housed in a low social stress environment rapidly developed large populations of northern fowl mites. Cockerels selected for high levels of plasma corticosterone and housed in a high social stress environment developed smaller populations of mites. Pullets were most resistant to infestation. Inherited levels of corticosterone had more effect on populations of this mite than did social stress alone. The interaction between social stress and plasma corticosterone was shown to have a significant effect upon parasite populations on cockerels.

FEASIBILITY OF SEED-CONTACT MANGANESE FERTILIZATION OF VA. TYPE PEANUTS. D. L. Hallock. Tidewater Research and Continuing Education Center, Virginia Polytechnic Institute & State University, Holland Station, Suffolk, Virginia 23437. Liming soils to pH 6.5 may cause manganese deficiency in peanut fields. Research elsewhere indicates inefficiency of broadcasting manganese. In-row applications were studied in 1974.

Granular manganese sulfate from a pesticide applicator was applied with the seed through the planter shoe at rates of 5, 10 or 15 lb/a manganese. In all cases, the 15 lb/a rate and on light sandy soils the 5 lb/a rate suppressed seedling emergence. However, final stands were similar. Manganese deficiency was precluded by the 5 lb/a rate in the row.

Seed-contact effects of granular manganese in Dragston fine sandy loam (less sandy) and Alga fine sand (very sandy) at two moisture levels were studied in the greenhouse. Under dry but not moist conditions in Alga soil, 1 lb/a manganese in the row suppressed seedling emergence and 3 or 5 lb/a rates caused severe root damage as well. These effects were insignificant in Dragston soil. Thus, application of manganese sulfate in the row when seedling peanuts probably is not feasible in very sandy soils which may be droughty.

DIETARY ZINC LEVELS FOR REPRODUCING SOWS DURING FIVE PARTURIES. J. D. Hedges, H. R. Thomas and E. T. Kornegay. Dept. of Animal Science, Blacksburg, Va. 24061 and Tidewater Research and Continuing Education Center, Suffolk, Va. 23434.

Dietary zinc levels of 33 (low) and 83 ppm (high) were compared using crossbred gilts (36 gilts per Zn level initially housed in total confinement and kept for five parturitions). The basal diet which was randomly assigned at the first mating was a 15% crude protein maize-soybean meal diet fortified with NRC minerals (except zinc) and vitamins. The diet was fed at an average level of 1.9 kg during gestation and 4.5 kg during lactation. NRC daily calcium and phosphorus requirements were fed. More total litters were farrowed by the high zinc fed sows although the number of sows that farrowed 5 parturitions was not different between dietary zinc levels. Sow serum zinc levels at weaning were higher ( $P < .05$ ) and there was a trend ( $P < .10$ ) for the zinc content of the sow hair and baby pig tails (coccygeal) to be higher for sows fed the high dietary zinc level as compared to sows fed the low zinc level. There were no significant differences in the number of pigs farrowed and weaned, average birth and weaning weight of pigs and the zinc content of baby pig testes. Zinc content of the liver and femur from a pig from each litter of the fourth and fifth parturitions were higher ( $P < .01$ ) when from sows fed the high dietary zinc level as compared to the low level; whereas, the zinc content of the spleen and kidney and the serum zinc levels were not significantly different.

THE INTERACTION OF A PREDACIOUS FUNGUS, ARTHROBOTRYS SP. AND A CYST NEMATODE, HETERODERA SOLANACEARUM ON TOBACCO. R. L. Hixon\* and J. A. Fox, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061.

Experiments were conducted in the greenhouse to investigate the interaction of a nematode trapping fungus, an unidentified species of *Arthrobotrys* with *Heterodera solanacearum*. Seedlings of *Nicotiana glauca* (N.C. 95) were transplanted into 15 cm pots containing a potting mixture (1 part soil: 2 parts Wehbit<sup>®</sup>, v:v) with the following treatments: (i) no treatment (check), (ii) oats (2% dry wt.), (iii) oats infested with *Arthrobotrys*, (iv) 20,000 *H. solanacearum* eggs, (v) oats and *H. solanacearum* eggs, and (vi) oats infested with *Arthrobotrys* and *H. solanacearum* eggs. Eight weeks after inoculation the mature female nematodes were removed from the root systems and counted. There were no differences in the dry shoot weight due to treatments. However the treatments containing the fungus had the smallest root systems and they were discolored. The number of females recovered per pot in treatments iv, v, and vi were 832.2, 362.4, and 291.6 respectively. Although these data suggest that the nematode trapping fungus reduced the number of females, factors relating to the addition of organic matter (oats) had the greater effect on the female numbers.

SOIL DEVELOPMENT IN COASTAL BEACHES AND SAND DUNES OF VIRGINIA BEACH, VIRGINIA. D. R. Hatch, J. E. Belshan, D. E. Starnes, D. E. Pettry, Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Soils in unconsolidated marine sediments were studied along a 2200 ft. transect from the present level of the Atlantic Ocean to the relic foredune near Cape Henry at Virginia Beach. Representative soil pedons were characterized and sampled according to landscape position (beach, berm, foredune). Organic matter and  $Fe_2O_3$  contents progressively increased with increasing distance from the beach indicating weathering and soil development. Chloride, soluble salt contents, and pH levels decreased in a similar proportional manner. Mineralogical analyses of the sand and silt fractions indicate quartz contents greater than 90% and feldspar contents ranging to 8%. Particle size analyses indicate the soils are comprised of 90% or greater sand sized particles.

INFLUENCE OF PREVIOUS SOW ZINC NUTRITION UPON FEEDLOT PERFORMANCE AND SERUM AND HAIR MINERAL CONTENT OF PROGENY FED TWO DIETARY ZINC AND CALCIUM LEVELS. J. D. Hedges, H. R. Thomas and E. T. Kornegay. Department of Animal Science, Blacksburg, Va. 24061 and Tidewater Research and Continuing Education Center, Suffolk, Va. 23434.

A study (two trials) involving 176 crossbred pigs (11.6 kg) was conducted to measure the effects of previous Zn nutrition of the sow, pigs (S<sub>1</sub>) and 83 (S<sub>2</sub>) ppm; dietary Zn, 33 (Z<sub>1</sub>) and 83 (Z<sub>2</sub>) ppm; and dietary Ca 0.8 (C<sub>1</sub>) and 1.4 (C<sub>2</sub>) in phase I, on serum and hair mineral content and feedlot performance of progeny from the fourth and fifth parturitions. A basal corn-soybean meal ration was fed ad libitum with protein and Ca levels being lowered at 18 and 45 kgs. Main effects were: For phases I and II, avg. daily gain was greater ( $P < .05$ ) for pigs fed Z<sub>2</sub>, for pigs from S<sub>2</sub> sows and less ( $P < .01$ ) for pigs fed C<sub>2</sub>. Overall phases daily gain was greater ( $P < .05$ ) for pigs fed Z<sub>2</sub> and less ( $P < .01$ ) for pigs fed C<sub>2</sub>. Feed intake for phases I and II was lower ( $P < .05$ ) for Z<sub>1</sub> and S<sub>1</sub>, although only Z<sub>1</sub> effected feed intake over all phases. Feed/gain ratios were increased ( $P < .05$ ) by C<sub>2</sub> overall phases. Serum Zn levels were increased ( $P < .01$ ) by Z<sub>2</sub>. Serum Ca levels were increased ( $P < .01$ ) by C<sub>2</sub>. Hair Zn content was higher ( $P < .01$ ) for pigs fed Z<sub>2</sub> and from S<sub>2</sub> sows. Hair Ca content was lower ( $P < .05$ ) for Z<sub>2</sub> and higher ( $P < .01$ ) for C<sub>2</sub>. Hair Fe content was higher ( $P < .01$ ) for C<sub>2</sub> and hair Cu was lower for C<sub>2</sub>. In general, pigs fed high Ca (C<sub>2</sub>) or low Zn (Z<sub>1</sub>) or pigs from S<sub>1</sub> sows had poorer feedlot performance.

AVAILABILITY OF NUTRIENTS IN SWINE FECES WHEN FED TO SWINE. M. R. Holland, E. T. Kornegay and J. D. Hedges, Department of Animal Science, VPI & SU, Blacksburg, Va. 24061.

Forty-eight crossbred gilts (125 kg) were used in a total collection metabolism study to determine the nutritive value of swine feces when fed to swine. Two trials of two replicates each were conducted to evaluate fresh and dried swine feces. Few differences were found for digestion of nutrients between the wet and dry trials. Dietary treatments for the two trials were: 1) basal (15% crude protein fortified corn-soybean meal), 2) basal substituted with 21.90% swine feces, and 3) basal substituted with 37.27% swine feces. The composition of the feces substituted on a dry basis was (X): crude protein 23.5, ether extract 8.0, crude fiber 14.8, ash 15.3 and nitrogen free extract 38.3. Feces substituted were collected from hogs weighing approximately 90 kg that were consuming a similar 15% crude protein fortified corn-soybean meal ration. The absorbed dry matter (ADMP), crude protein (ACPPI), crude fiber (ACFPFI), ash (AAPFI), ether extract (AEEPI) and nitrogen free extract (ANFEPI) as a percent of intake significantly decreased as the dietary level of manure increased. Retained nitrogen as a percent of intake (RNPI) and retained nitrogen as a percent absorbed were not significantly affected. Based on regression analysis, the extrapolated values were (X): ADMP 48.6, ACPPI 58.5, ACFPI 39.5, AAPI 30.5, AEEPI 54.2, ANFEPI 37.5, RNPI 20.9 and RNPA 35.8.



AN ECONOMETRIC MODEL OF VIRGINIA'S SHORT-TERM FOREST PRODUCTS MARKETS. **Hovetved, James E.\*** and William A. Leuschner.\* Department of Forestry and Forest Products, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

A short-term model simulating consumption of Virginia's primary woods products is presented. The sawlog, veneer log and pulpwood markets and their interrelationships are described using a system of 15 simultaneous equations and identities. The two stage least squares regression technique is used to determine the structural coefficients of the demand, supply, and consumption equations associated with each market, and the resultant system is used to simulate equilibrium consumption of each product over the study period.

The short-term model proved to be a reasonable simulator of the primary woods products markets. Generally, changes in estimated consumption followed changes in observed consumption. Furthermore, the average annual absolute percentage difference between estimated and observed consumption for the individual markets range from 3.94 to 10.01 percent. As a result, it is concluded that the short-term model should also simulate future consumption patterns with a fair degree of reliability. (Research supported by McIntyre-Stennis funds).

HEIGHT OF STUBBLE CUT AND STRAW MULCH CONCENTRATION EFFECTS ON YIELD AND CERTAIN AGRONOMIC CHARACTERISTICS OF NO-TILLAGE PLANTED SOYBEANS. PART II. **C. H. Hovetved\***, M. W. Alexander, H. M. Camper\*, Department of Agronomy, Blacksburg, Va. 24061, Tidewater Research and Continuing Education Center, Suffolk, Va. 23437, Eastern Va. Research Station, Warsaw, Va. 22572. The effect of three stubble heights and three straw mulch rates on certain agronomic characteristics of soybeans no-tillage double-cropped after small grain was studied at two locations for three years. Straw residue associated with a stubble height after harvest is designated X, twice this amount 2X and all removed 0. The three stubble heights were: 'low' (10.2 cm), 'medium' (20.3 cm) and 'high' (35.6 cm) at Warsaw and 40.6 cm at Suffolk. Early season plant growth as determined by height measurements increased with taller stubble. Less mulch at Warsaw and more mulch at Suffolk increased plant growth. Mature plants at Warsaw were taller in the high stubble with no difference between the low and medium stubble; the same trend was shown at Suffolk. The X and 2X mulch at Warsaw and X mulch at Suffolk produced taller plants. Lodging and pod height followed the same trend as plant height. Canopy widths measured in 1973 only showed that taller stubble and lower mulch treatments covered rows first. Mulch and stubble treatments did not affect seed size and oil content. Protein was higher under 2X mulch at Warsaw and X mulch at Suffolk. Soil moisture at Warsaw for two years in the 10-15 cm layer was highest under 2X mulch. Stubble effects on moisture were not consistent.

CURRENT STATUS OF BIOLOGICAL WEED CONTROL PROJECTS IN VIRGINIA. **L. T. Kok**, Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061.

One of the two current major projects on biological weed control in Virginia involves determination of the indigenous insect fauna of 15 economic weeds. Regular sampling, from 3 sites for each host, were conducted during 1972-74. Insects showing promise for further study include: *Papilio arcti-vorens* (stemborer) on giant ragweed; *Oidematophorus monodactylus* (leaf and flower feeder) on bindweed; *Leptinotarsa juncea* (defoliator) on horse-nettle; *Cassida rubiginosa* on *Carduus* thistles, and *Paralobesia carduana* (stalk-borer) on bull thistle. Biological studies are in progress to evaluate their potential as biocontrol agents.

The second project utilizes two imported thistle-feeding weevils for control of *Carduus* thistles. *Rhinocyllus conicus* a French thistle-head feeder, initially released in 1969, has been established in many pastures and young pine forests infested with thistles. This weevil has demonstrated noticeable control of musk thistle (*Carduus nutans*) and its damage to seeds is being evaluated. *Ceuthorrhynchus horridus*, an Italian rosette-feeder, was officially approved for release in June 1974 after three years' intensive host specificity testing confirmed that it does not attack plants other than thistles. It was released in the fall of 1974 and current emphasis is on field establishment and evaluation of its efficacy in thistle control. (Aided by CSRS Grant #4234751 and State Project #2002900).

SOIL, CORN PLANT AND GRAIN MINERAL LEVELS FOLLOWING THREE YEARS OF APPLYING FERTILIZERS FROM PIGS FED HIGH AND LOW DIETARY COPPER LEVELS. **E. T. Kornegay**, J. D. Hedges and D. C. Martens. Departments of Animal Science and Agronomy, Blacksburg, Va. 24061

Manure from finishing pigs fed diets with and without a growth stimulating level of added Cu (average 310 ppm) was incorporated into a Groseclose silt loam at an average rate of 14.7 metric tons of dry matter per hectare, respectively, for 1972, 1973 and 1974. A third treatment was no manure. The manure was applied when corn was about 10 cm tall and incorporated into the surface 10 cm of the soil. The average composition of the manure for the three years on a dry basis was 3.62 N, 2.872 Ca, 0.932 Mg, 2.222 P, 1.302 K, 648 ppm Zn, 2191 ppm Fe. The Cu content of the two manures was 73 ppm and 1719 ppm. Copper content in the upper 10 cm of the soil was significantly increased each year when high Cu manure was applied. During one growing season Cu did not move down, however, plowing after the first year increased the Cu level in the 10-20 cm depth with a small increase in the 20-30 cm depth. Potassium, Zn, P, Ca and Mg levels of the soil increased from manure application. There was a small increase in the Cu content of the maize ear leaf (average of one ppm per year) when manure containing high Cu was applied. Copper content of grain was not increased for either year. The Zn, K and P contents of the ear leaf were increased slightly; whereas, Fe and Ca contents of the ear leaf were not affected by manure application.

LYSINE AND PROTEIN EVALUATION OF COMMERCIAL GROWN OPAQUE-2 AND NORMAL CORNS. TWO YEAR SUMMARY. **E. T. Kornegay**, H. R. Thomas, J. D. Hedges and K. E. Webb\* Dept. of Animal Science, Blacksburg, Va. 24061 and Tidewater Research and Continuing Education Center, Suffolk, Va. 23434

Fifty-eight samples (30 in 1973 and 28 in 1974) of commercially grown opaque-2 corn and twenty-eight samples (10 in 1973 and 18 in 1974) of normal corn were obtained from several locations in Virginia for the determination of the lysine and protein content. All values are expressed on a 90% dry basis. The lysine content of opaque-2 corn was  $.37 \pm .007$  (mean  $\pm$  SEM) % in 1973 and  $.36 \pm .006\%$  in 1974. In normal corn the lysine content was  $.25 \pm .004\%$  in 1973 and  $.26 \pm .003\%$  in 1974. The protein content of opaque-2 corn was  $8.4 \pm .22\%$  in 1973 and  $8.6 \pm .16\%$  in 1974. In normal corn, the protein content was  $8.7 \pm .13\%$  in 1973 and  $8.5 \pm .22\%$  in 1974. Yields obtained only in 1974 were nonsignificantly lower (6.7%) for opaque-2 corns as compared to normal corn grown on the same farm. There was a positive linear correlation between protein and lysine content of opaque-2 corn with a derived prediction equation of  $Y = .044X - .002$  ( $r = .59$ ;  $P < .01$ ) in 1973 and  $Y = .032X + .084$  ( $r = .80$ ;  $P < .005$ ) in 1974;  $Y = \%$  lysine and  $X = \%$  protein. For the combined years the prediction equation was:  $Y = .037X + .051$  ( $r = .63$ ;  $P < .005$ ). The relationship between protein and lysine in normal corn was not nearly so great. In 1973, the regression was nonsignificant and in 1974 the regression was significant only at the 5% level. For the combined years it was nonsignificant.

GENERATING PRECIPITATION EXCESS BASED ON READILY DETERMINABLE SOIL CHARACTERISTICS. **R. A. Li\***, V. O. Shanholts\*, Agricultural Engineering Dept., and D. N. Contractor\*, Civil Engineering Dept., Va. Polytechnic Inst., Blacksburg, Va. 24061

Soil texture, depth of the A horizon, soil hydrology group, and ture were used to categorize areas which respond similarly to a given rainfall event. A computer algorithm was structured to generate precipitation excess (unrotated runoff) for each response unit using an infiltration equation. Model parameters were correlated with readily determinable soil characteristics.

Specific land use alterations or modifications can be imposed, potential rainfall excess generated, and these flows routed from their origin to any downstream point of interest. Surface flow depths and velocities can be computed throughout the watershed by interfacing the precipitation excess generator with an appropriate routing model. The impact of a specific land use change on the receiving stream can be more easily assessed following this approach. (Aided by OWRG grant A-062-VA)



RELATIONSHIP BETWEEN WHITE CLOVER AND SEVERITY OF PEANUT STUNT VIRUS IN PEANUTS. D. M. Porter, J. C. Smith and R. W. Mazingo. USDA, ARS and Tidewater Res. and Continuing Education Ctr., Suffolk, VA 23437

Severe symptoms of peanut stunt virus (ESV) were observed in a peanut field adjacent to a roadway having white clover planted along its edges. Most all plants in the first eight rows of peanuts running parallel to the white clover growing on the edge of the roadway were infected with ESV. Severity of ESV decreased with distance and symptoms were not observed 81 feet or 27 rows away from the white clover. Insecticides including disulfoton, carbofuran and phorate, incorporated in research plots within the same field for tobacco thrips (*Frankliniella fusca* Hinds) control also greatly reduced the severity of ESV. Rod yields in untreated and carbofuran-treated plots located 6-9 feet from the white clover were 582 pounds and 1128 pounds per acre, respectively. Yields in similar untreated and treated plots 100 feet away from the white clover where ESV was not present averaged over 2400 pounds per acre. Market grade components and values per acre also decreased with increased ESV severity. Similar trends were noted in other research plots.

USE OF FALSE COLOR INFRARED PHOTOGRAPHY TO DETECT CYLINDROCLADIUM BLACK ROT DISEASE IN PEANUT FIELDS. N. L. Powell, and D. E. Pettry. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Aerial surveys were conducted over portions of the peanut growing region of Virginia to determine the spectral, spatial, and temporal characteristics of *Cylindrocladium* black rot disease in peanut fields utilizing false color infrared imagery. The disease is a soil-borne fungus caused by *Cylindrocladium crotalariae*. The disease can be detected on the imagery taken as high as 19,704 m above the earth's surface. The disease, with its unique spectral signature, is easy to distinguish from other diseases of peanuts such as Sclerotinia blight. Disease patterns which are difficult to observe from the ground are easily detected on the aerial photography. Early detection of the disease by aerial surveys will permit prompt control measures to minimize spread of the disease. Also, information from this study will provide permanent records that can be used to monitor the change in extent and severity of the disease in future growing seasons. Imagery evaluation indicates that *Cylindrocladium* black rot disease is widespread in the peanut growing region of Virginia. (Supported in part by NASA contract NAS6-2388).

PEDEGENIC INVESTIGATION OF TIDAL MARSH SOILS IN VIRGINIA BEACH AND GLOUCESTER COUNTY, VIRGINIA. G. Reusch\*, D. E. Pettry, J. E. Belesan, W. F. Kitchel, and H. E. Newman. Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Information is lacking on the tidal marsh soils of Virginia which comprise about 200,000 acres. Soil transects were made of representative areas to characterize and sample 75 pedons. Organic matter accumulated in the marsh areas under saturated conditions with levels in surface horizons ranging from 6.8 to 88%. Pedons high in organic matter extended to depths of 80 inches in Virginia Beach. Electrical conductivity values of soil extracts ranged from 2-8 mhos in Virginia Beach to 8-25 mhos in Gloucester County. Variable contents of reduced sulfur were detected in the soils. Sulfates from sea and rain water are reduced to sulfides. If sulfidic material is oxidized, sulfuric acid is produced drastically lowering the pH. The monitored drying of selected profiles have shown a pH decrease to 2.8. These soils are typically near neutral when in the natural condition. Mineralogy in these areas is mixed, with a considerable portion represented by various 2:1 clays, and intergrades to 2:2. Vermiculite, chloritized vermiculite, chlorite, montmorillonite, illite, and kaolinite are present in various quantities.

BIOLOGY AND CONTROL OF THE ALFALFA WEEVIL IN VIRGINIA James E. Roberts, Sr. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061

The alfalfa weevil was first reported from Virginia in 1952. By 1958 it had spread over the State and by 1962 it had covered the entire state. Control of the insect was not difficult as long as heptachlor was effective and approved for use on alfalfa. With this insecticide no longer approved for use, farmers had difficulty in obtaining effective control. From 1961 to 1967 the acreage of alfalfa in Virginia declined from 260,000 to 82,000 acres. It has been observed that infestations of the alfalfa weevil are more severe at lower than at higher altitudes in Virginia, and that injury in the spring begins earlier in relation to the growth stages of alfalfa at lower altitudes. The weevil can be controlled with presently recommended insecticides; namely, Azinphosmethyl (Guthion), Carbofuran (Furadan), Imidan, Malathion (Cythion), Parathion, and Supracide.

AN EVALUATION OF MEXICAN BEAN BEETLE RESISTANCE IN 'SHORE' VARIETY SOYBEANS IN TIDEWATER VIRGINIA. J. C. Smith and M. W. Alexander. Tidewater Res. and Cont. Ed. Ctr., VPI & SU, Suffolk, Va. 23437

'Shore' variety soybeans have been classified as a Mexican bean beetle (Mbb)-resistant cultivar exhibiting both non-preference and antibiosis. Shore was evaluated at Holland for Mbb-resistance in tests from 1971-4 and for yield and other quality factors in 1972-4. The value of Mbb-resistance was determined by comparing yields and seed size of both untreated and systemic-treated plots. Shore produced 18% larger yields than 'York' (Mbb-susceptible) in 1973 when infestations were severe. When the two cultivars were treated with systemic insecticides, York yields were 8% greater than Shore. Early frosts prevented full maturation of Shore in 1974 tests, and Shore failed to produce higher yields in either an untreated or systemic-treated condition. There was little visual difference in Mbb-foliar feeding on Shore and York in 1974, but these differences were apparent in prior years of testing. Seed size of Shore was reduced an average of 15.5% due to Mbb-defoliation, while York seed size was reduced by 24%.

COMPARISON OF THREE SUCCESSFUL COLONIZATIONS OF AN INTRODUCED WEEVIL FOR BIOLOGICAL CONTROL OF THISTLES.

W. W. Surles, L. T. Kok, and R. L. Plenkowski\*. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061

The colonization of *Rhinocyllus conicus*, a weevil imported from France for the biological control of *Carduus* thistles, was compared for releases on: musk thistle (*Carduus nutans* L.) in Loudon Co.; plumeless thistle (*Carduus acanthoides* L.) in Highland Co., and a mixed stand of musk and plumeless thistle in Frederick Co. Weevils imported in 1969 in collaboration with the USDA and Commonwealth Institute of Biological Control, were released in 1970. Surveys were conducted in 1971 and 1972 to assess degree of the insects' colonization and dispersal. Colonization was more successful on the musk thistles and on the mixed stand probably due to better uniformity of plant distribution. It was less successful on plumeless thistles due to poor synchronization of weevil and host emergence. Dispersal was slow (150 m) during the first two years, and no specific mode of orientation was detected. (Supported in part by the Virginia Agricultural Foundation.)

FEED CONSUMPTION OF DWARF AND NONDWARF PULLETS FROM DIFFERENT GENETIC BACKGROUNDS. D. A. Sutton\*, P. R. K. Reddy\* and P. B. Siegel. Poultry Dept., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Reproduction and feed utilization of dwarf and normal pullets from lines of White Rock chickens selected for high and low juvenile body weight were compared under restricted and ad libitum feeding regimes. Although rankings of genotypes for body weight and reproductive traits were consistent for both feeding regimes, their relative influences on feed consumption varied considerably suggesting that energy allocation is a function not only of genotype and method of feeding, but also of an interaction of genotype by feeding regime. Furthermore, some of the differences in feed efficiency of dwarf and normal pullets within a line may be attributed to items other than body size.

EVALUATION OF ROASTED CORN AND SOYBEANS FOR SWINE. H. R. Thomas and E. T. Kornegay, Tidewater Research and Continuing Education Center, Suffolk, Va. 23434

Ninety-six crossbred pigs (4 pens of 6 pigs per treatment) averaging 50.4 pounds initially were used to evaluate roasted corn and soybeans in swine rations. Dietary treatments were: 1) normal corn (NC)-soybean meal (SBM), 2) roasted corn (RC)-soybean meal (SBM), 3) normal corn (NC)-roasted soybeans (RSB), 4) roasted corn (RC)-roasted soybeans (RSB). All rations were fortified with minerals, vitamins and antibiotics to meet NRC recommendations and were fed ad libitum. The study lasted 95 days with the final weights of the pigs being approximately 185 pounds. In this trial, avg. daily gains (lbs), daily feed intake (lbs) and feed/gain ratios, respectively, were: ration 1- 1.52, 4.45, 2.93; ration 2- 1.58, 4.81, 3.05; ration 3- 1.40, 4.20, 3.00; ration 4- 1.42, 4.31, 3.05. Main effect means for avg. daily gains (lbs), daily feed intake (lbs) and feed/gain ratios, respectively, were: SBM- 1.54, 4.63, 2.99; RSB- 1.41, 4.26, 3.02; NC- 1.46, 4.32, 2.96; RC- 1.50, 4.56, 3.04. Avg. daily gains and daily feed intake were significantly greater ( $P < .05$ ) with rations containing soybean meal than with rations containing roasted soybeans. A trend was observed ( $P < .10$ ) for more efficient gains (feed/gain ratio) when rations containing normal corn were fed as compared to rations containing roasted corn. Other criteria were not significantly different.

FAILURE OF SUPPLEMENTAL ZINC-PROTEINATE, ZINC SULFATE AND METHIONINE TO STIMULATE GROWTH RATE AND FEED EFFICIENCY OF SWINE. H. R. Thomas and E. T. Kornegay, Tidewater Research and Continuing Education Center, Suffolk, Va. 23434 and Department of Animal Science, Blacksburg, Va. 24061

One hundred-fifty crossbred pigs (trials 1 and 2) and 166 crossbred pigs (trials 4, 5 and 6) were used to evaluate a zinc-protein complex (ZPC) as a growth stimulant for growing and finishing pigs. Dietary treatments were: 1) low zinc (30 ppm Zn), 2) diet 1 plus 0.1% ZPC (120 ppm Zn), 3) normal zinc (80 ppm Zn), 4) diet 3 plus 0.1% ZPC (170 ppm Zn), 5) high zinc (170 ppm Zn) and 6) diet 3 plus DL-methionine (80 ppm). A fortified corn-soybean meal-peanut meal-fish flour diet was self-fed in trial 1 with peanut meal omitted in trial 2. A fortified corn-soybean meal diet was self-fed in trials 3, 4 and 5. The addition of ZPC or zinc sulfate to a grower or finisher ration with (normal) or without (low) supplemental zinc was ineffective in improving average daily gain, feed intake or feed efficiency. In the fourth and fifth trials when DL-methionine was added at a level to equal the methionine in the ration containing ZPC, average daily gain, feed intake and feed efficiency were not different between treatments. No problems were experienced with parkeriosis for even the pigs fed the low zinc rations although this level is less than recommended by the National Research Council.

PRELIMINARY ATTEMPTS TO CONTROL THE VARIEGATED LEAFROLLER, *PLATYNOTA FLAVEDANA* GLENNES (LEPIDOPTERA: TORTRICIDAE).

John H. Thomas\* and Clarence H. Hill, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061 and Winchester Fruit Res. Lab., Winchester, Va. 22601. Variegated leafroller, *Platynota flavedana*, damaged 47% of the untreated apples in an experimental orchard in Winchester, Virginia. Most of the damage was caused by the first generation. Eleven different treatments were applied dilute at two week intervals, for six cover sprays starting on July 8, 1974 and ending September 9, 1974. The treatments were evaluated in midseason by timed counts of larval habitats and at harvest by examination of fruit.

The standard orchard insecticides, azinphosmethyl, Imidan and phosalone did not give adequate control. Four different plots of *Bacillus thuringiensis* were applied and all of the treatments gave better control than the standard commercial insecticides. An insect growth regulator was tested and proved effective in preventing adult emergence but was not effective in controlling the population size nor preventing fruit damage by the larvae. When evaluated at harvest, Phosvel, an experimental compound, displayed outstanding efficacy compared to registered materials.

A PRACTICAL TECHNIQUE FOR SURVEYING AND PROCESSING WEED-FEEDING INSECTS. J. T. Trumble\*, L. T. Kok and R. L. Pienkowski\*, Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061.

A simple polyethylene-bag sampling technique was used in surveying insects associated with 10 selected economic weeds. Samples were taken at regular intervals by inverting large polyethylene bags 23" x 17" x 48" over the target weed in the field, and fastening the open end with strong rubber bands or string. The plants were then uprooted with a two-pronged soil digger, labeled and processed in the laboratory. Fifty percent of the samples were dissected immediately; the remainder were separated into leaves, stems and roots and placed in ventilated clear polyethylene bags. These bags were hung from lines stretched across the ceiling of the room and daily observed for emergence of adult insects. Emerging adults fly towards the apical portion of the bag and are clearly visible. Adults were removed as they emerged, and correlated with immatures collected during dissection before being sent for determination. Samples hung in this manner were observed for 21 days and then dissected. All insects recovered were recorded and the bags reused. This technique is simple, economical, efficient, and allows samples to be rapidly processed with maximum insect retrieval. (Aided by CSRS Grant #4234751)

THE STATUS OF ENTOMOLOGY IN HAITI, WEST INDIES. R. H. Ward. Dept. of Entomology, VPI&SU, Blacksburg, Va. 24061.

Results of a preliminary investigation conducted between Jan. 22 and Feb. 10, 1975 under the auspices of the Inter-American Institute of Agricultural Sciences (IICA), a specialized branch of the OAS, indicate a need for the strengthening of existing institutions and the establishment of new agencies to meet the demands of present day pest control problems. Improvement of the institutional systems of rural sectors, IICA's main objective, involves strengthening agricultural administration policy, agricultural education, research, production and marketing. The development of entomological aspects could be carried out through an expansion of current programs.

To meet present and future pest control problems the establishment of centralized governmental coordinated regulatory, extension, and pest management agencies was recommended. The regulatory agency would help to prevent the further entry and establishment of foreign plant and animal pests and eradicate, contain, or suppress pests established in limited areas. The extension agency would gather and disseminate basic and applied research data pertaining to crop pests and diseases and their controls. The pest management agency would approach pest control problems from ecological bases for each major crop agro-ecosystem in an attempt to avoid the disaster phase of the pesticide syndrome.

## Abstracts of Papers

# Section of Astronomy, Mathematics, and Physics

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

SOME QUICKIE PHYSICS DEMONSTRATIONS. D. Rae Carpenter, Jr., Department of Physics, Virginia Military Institute, Lexington, Va. 24450

Some of the most elegant demonstrations from a pedagogic point of view are the simplest and quickest to show. Several will be given:

- a. Use of an engraved steel ruler as a reflection grating with the laser including the effect of different length rulings
- b. A wooden block with felt tip pens on a strip of wrapping paper to illustrate uniform motion of center of mass of a rotating object
- c. Conservation of angular momentum with the balance wheel of a pocket watch using a laser with a long optical lever.

PHOTOIONIZATION CROSS SECTION OF THE  $3p$  GROUND STATE OF NEUTRAL CARBON. S. L. Carter\* and H. P. Kelly\*, Dept. of Physics, University of Va., Charlottesville, Va. 22901

The photoionization cross section of the  $2p$  and  $2s$  subshells of the  $3p$  ground state of neutral carbon has been calculated including correlation effects. Resonances due to the  $1s^2 2s 2p^2 np$  autoionizing configurations and two-electron resonances from the  $1s^2 2s^2 3s 3p$  and  $1s^2 2s^2 3p 3d$  configurations were calculated. Detailed agreement is obtained with the experimental data of Esteve, Mehlman-Balloffet, and Romand. (Supported by National Science Foundation)

AN ANALYTICAL AND EXPERIMENTAL STUDY OF CAPITANCE MICROPHONES. Norman Cohen\*, Department of Physics & Geophysical Sciences, Physics Research Labs, Old Dominion University, Norfolk, Virginia 23508.

The objective of this research is to develop a high temperature transducer ( $800^\circ\text{F}$ ) capable of measuring pressure fluctuations within the exhaust of a jet aircraft. To measure these fluctuations, a prototype capacitance microphone cartridge has been constructed, and preliminary tests have been conducted. A microphone carrier system with automatic tuning to compensate for sensitivity to temperature changes, and half wavelength cable for remote location of electronics are being used. Response curves at room temperature and pressure are compared to those predicted by theory.

ACTIVATION ANALYSIS AS AN ARCHAEOLOGICAL TOOL. Frederick C. Davison, Jr.,\* Dept. of Physics, VMI, Lexington, Va. 24450.

Neutron activation analysis has proved to be a useful method for archaeologists in determining trace element composition in ancient ceramics. By comparing analyses of clay artifacts with modern day sources, it is possible to determine the location of manufacture of certain ancient objects. We have used this technique to analyze 3100 year old artifacts of the Olmec culture, which prospered in the central and highland regions of Mexico. Broken clay figurines were obtained from four Olmec sites. Each of these figurines was drilled with a carbide bit, then the sample material was collected and packaged for irradiation in the University of Virginia's research reactor. By normalizing with known standards, trace element composition has been determined. The comparison of results has made it possible for artifacts from one area to be traced to the original site of manufacture. This has provided evidence to archaeologists in the determination of trade routes and conceivably could lead to the discovery of the origin of Central American civilization.

## SEMI-OPEN-PHYSICS-LAB AT W.C.C.

Richard Dehart, Y. P. Hwu

Wytheville Community College

Experiences on the Semi-Open-Physics-Lab at W.C.C. last year to the high school seniors and science teachers has been discussed.

CROSS SECTIONS FOR DAUGHTER NUCLEI STATES FROM THE INTERACTION OF 190 MeV  $\pi^+$  WITH  $^{40}\text{Ca}$ . C. M. Dennis<sup>a</sup> and C. E. Stronach, Dept. of Physics, Va. State Col., Petersburg, Va. 23803, B. J. Lieb, Dept. of Physics, George Mason Univ., Fairfax, Va. 22030, H. O. Funsten and W. J. Kosler<sup>a</sup>, Dept. of Physics, Col. of William and Mary, Williamsburg, Va. 23185, H. S. Plendl<sup>a</sup>, Dept. of Physics, Fla. State Univ., Tallahassee, Fla. 32306.

The spectrum of prompt  $\gamma$  rays coincident with 190 MeV  $\pi^+$  on a calcium target was observed with a Ge(Li) detector at the SREL<sup>1</sup> synchrocyclotron. This spectrum contained peaks from  $^{40}\text{Sc}$ ,  $^{40}\text{Ca}$ ,  $^{39}\text{Ca}$ ,  $^{39}\text{K}$ ,  $^{38}\text{K}$ ,  $^{37}\text{Ar}$ ,  $^{36}\text{Ar}$ ,  $^{35}\text{Cl}$ ,  $^{34}\text{S}$ ,  $^{32}\text{S}$  and/or  $^{30}\text{Si}$ ,  $^{31}\text{P}$  and/or  $^{30}\text{Si}$  and/or  $^{29}\text{Si}$ ,  $^{28}\text{Si}$ , and  $^{24}\text{Mg}$ . The third excited state of  $^{40}\text{Ca}$  and the first excited state of  $^{28}\text{Si}$  (87.5 mb) were Doppler broadened with mean recoil momenta of about 190 MeV/c and 415 MeV/c respectively. A  $\gamma$  spectrum was also taken in coincidence with outgoing pions at  $30^\circ$  with respect to the incident beam. Comparisons will be made with results from 220 MeV  $\pi^-$  and  $\pi^+$  absorption on  $^{40}\text{Ca}$ , and with statistical evaporation calculations. (Aided by NASA grant NGR 47-014-006)

<sup>1</sup> The Space Radiation Effects Laboratory is supported by the NSF, NASA, and the Commonwealth of Virginia.

A NOMOGRAM FOR MIXING A GAS WITH THE VAPOR OF A LIQUID IN PRESCRIBED PROPORTIONS. L. Ivan Epstein, Dept. of Bio-physics, and Bernard A. Kuzava\*, Dept. of Nurse Anesthesia, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298.

In an anesthesia machine, oxygen is charged with saturated vapor of a liquid anesthetic. The resulting mixture is then diluted with sufficient oxygen to produce a prescribed mole percentage of anesthetic. The mixing takes place at a pressure of 800 torr. A set-square nomogram<sup>1,2</sup> has been constructed for the new anesthetic Iso-Flurane. Its scales show temperature, total flow to the patient, desired mole percent concentration of anesthetic, and required flow to the vaporizer.

<sup>1</sup> L. I. Epstein: Nomography (Interscience, 1958)

<sup>2</sup> J. P. Vitcha, Anesthesiol. **35**, 4 (1971)

M. L. Nahwold et al., Anesthesiol. **32**, 444 (1973)

AN EXPERIMENT FOR DETECTING CHANGES IN THE UNIVERSAL GRAVITATIONAL CONSTANT. G.T. Gillies,<sup>a</sup> R.C. Ritter, R.A. Lowry, and J. W. Beams. Dept. of Engineering Science and Systems and Dept. of Physics, Univ. of Va., Charlottesville, VA 22901

Beams has proposed that, with certain modifications in his method of measuring the absolute value of  $G$ , one could observe changes in  $G$ . The apparatus would consist essentially of a Cavendish balance supported on a rotary table. The apparatus would be shielded and cooled to approximately 0.01° Kelvin in order to minimize noise problems. To sense changes in  $G$  to an accuracy of  $10^{-11}$ , the effects of local mass distributions must be averaged out. Hence, the rotary table must be driven at an angular velocity which is constant to at least a part in  $10^9$  per revolution.

Progress on efforts toward attaining this type of table motion are reported here, as well as tests on the table in an undriven mode.

## JUPITER'S GREAT RED SPOT: NEW LIGHT ON AN OLD MYSTERY.

W. A. Griffin\*, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508

Jupiter's Great Red Spot - a unique, visible feature of the planet; apparently discovered circa 1665 by Cassini - has long been an enigma.

Prominent models proposed to explain the GRS include: Floating Island Hypothesis, Taylor Column Theory, Cartesian Diver Hypothesis, and Tropical Storm Theory. Each of these models is examined in the light of recent Earth-based observations and, especially, the substantive data from NASA probes Pioneer 10 and 11. It is concluded that the Tropical Storm Theory of the late G. P. Kuiper (1, 2) is in best agreement with recent observations.

1. Kuiper, G.P.: Jan. 1972, Sky Telesc. Vol. 43/1

2. Kuiper, G.P.: Feb. 1972, Sky Telesc. Vol. 43/2

SPINNING METHODS OF TESTING THE TENSILE STRENGTH OF VERY SMALL SPECIMENS. Ofelia Hodgins\*, Dept. of Materials Science University of Va., Charlottesville, VA 22901

Ultracentrifuge techniques for the tensile testing of small specimens originally developed by Dr. Jesse W. Beams in 1933 are being modified to allow testing of very small metal hairs i.e., whiskers.

Previous comparable work by Beams and Piotrowski was limited to crystals of diameters larger than 100  $\mu$ m.

The present modifications are directed towards testing of small diameter polycrystalline iron whiskers (Schladitz whiskers) that have not been subjected to prior deformation by cutting.

Critical theoretical parameters for the procedure will be discussed along with the various components of the system.

## ONE CALL, COVERS IT ALL

William Horton, Jeffrey Baxley, Y. P. Hwu  
Wytheville Community College

Use Inertia Wheel to verify some relations on the motion of a particle and the motion of a rigid body, and also some relations between angular and linear quantities.

## MULTIPLE USE OF A SPARK TIMER

Sidney L. Kitts, Randy Felts, Y. P. Hwu

Wytheville Community College

Spark timer has been used to verify:

1. conservation of mechanical energy
2. simple pendulum as a simple harmonic motion

NONLINEAR CAPILLARY INSTABILITY AND BREAKUP OF LAMINAR LIQUID JETS. P. Lafrance\*, Dept. of Physics, Univ. of Va., Charlottesville, VA 22901.

A perturbation analysis of the capillary instability of an inviscid liquid jet was carried out to third order. The results show that the nonlinear terms are responsible for the presence of satellite drops. A computer implementation of this theory shows that predicted surface wave profiles, disturbance amplification rates and drop sizes are in substantial agreement with experimental data.

Experiments were performed to measure the size of drops resulting from the capillary breakup of laminar liquid jets. Random noise was used as a perturbation and the drop spectrometer measured the resulting drop size distributions. These distributions are bimodal and correspond to the two species of drops predicted by the nonlinear theory.

Electron Spectroscopy with an Automated Detection System. David Nicholson, Bob Chiavellio, and W. Barlow Newbolt; Washington and Lee University. During the summer of 1975, Ed Turner and Brian Whitehurst developed the software and the computer interfaces necessary to use the surplus D17B to control a single channel analyzer and store the total counts obtained for each channel. We have adapted that system for use with a small, Li-drifted, silicon detector to measure internal conversion lines and beta spectra. Although we have had some difficulty dividing the energy scale finely enough to study conversion lines, our measurement of the beta spectrum of  $^{60}\text{Co}$  indicates that this is reasonably good way to study beta spectra.

ELECTRON EXCITATION OF HYDROGEN. M. S. Pindzola\* and H. P. Kelly, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

The 2s and 2p excitation cross sections for electron scattering on hydrogen in the energy range from threshold to 50 eV are calculated by two similar methods. The distorted-wave method using Hartree-Fock continuum wave functions in the frozen-core approximation is applied. The effect of calculating the distorted waves in the potential of the initial or final state is investigated. The imaginary part of the optical potential, or self-energy of the single particle Green's function, is also calculated in lowest order by the use of many-body diagrams. Comparison is made with recent experimental results. (Research supported by NSF)

PAIR REACTANCE AND QUASIPARTICLE CONDUCTANCE OF A PHASE BIASED SUPERCONDUCTING WEAK LINK. Robert Rifkin\* and Bascom S. Deaver, Jr., Physics Dept., Univ. of Virginia, Charlottesville, Virginia 22901.

The current flow between two weakly coupled superconductors was shown by Josephson to be given by

$$I = I_c \sin \phi + C_0 (1 + \alpha \cos \phi) V,$$

and  $\frac{d\phi}{dt} = \frac{2eV}{\hbar}$ , where

$I_c$  is the critical current of the weak link,  $V$  the voltage across it,  $\phi$  the quantum-mechanical phase difference across the link, and the coefficient of  $V$  can be considered to be a phase dependent quasiparticle conductance. The first term is the pair current and corresponds to the current flow through an effective inductance  $L = \hbar/2eI_c \cos \phi$ . Measurements of the impedance of a 10 point contact have been made and compared with the values calculated from the Josephson equations. For small  $I_c$  there is good agreement, but for larger  $I_c$  the agreement deteriorates. These measurements indicate that the coefficient  $\alpha$  is negative. (Research supported by the National Science Foundation.)

OBSERVATION OF THE  $\text{CuK}\alpha$  SPECTRUM BY MEANS OF A NEW HIGH RESOLUTION TECHNIQUE, William C. Sauder, Dept. of Physics, VMI, Lexington, Va. 24450 and R. E. LaVilla\*, National Bureau of Standards, Washington, D. C. 20234

We report the observation of satellite structure in the  $\text{CuK}\alpha$  spectrum arising from transitions between double vacancy states  $1s3d^3 \rightarrow 2p^3 3d^3$  and  $1s3p^2 \rightarrow 2p^3 3p^3$ . This has been accomplished by means of a double crystal Bragg case x-ray spectrometer fabricated from a single crystal of dislocation-free silicon. This monolithic spectrometer, scanned by rotation of the device about an axis in the horizontal dispersion plane so as to change the mean vertical divergence angle, is characterized by high dispersion and is capable of very high resolution as a result of the inherent stability of the dihedral angle between the diffracting planes. Experimental and theoretical results are discussed and compared.

NMR IN AMORPHOUS ALLOYS. H. E. Schone, Col. of William and Mary, K. S. Han, Hampton Institute.

We have studied the  $V^{51}$  NMR in thin films of  $V_{50}Zr$  alloys prepared in the amorphous state by sputtering onto a water cooled copper substrate. We find that the line in the amorphous sample is considerably broader than that in pure vanadium with a field dependence which indicates a disordered electronic structure. There is also a decrease in intensity which we ascribe to quadrupole splitting due to interstitial gas atoms and structural disorder. Annealing dramatically narrows the line and increases the intensity, indicating either a phase change or disappearance of a large number of lattice defects. The Knight shift is changed very little in going from pure V to the amorphous state.

RESONANT EXCITATION OF ISOMERIC STATES BY MEANS OF MOSSBAUER EFFECT. J. J. Singh, NASA Langley Res. Ctr., Hampton, Va. 23665

Recent availability of a high efficiency backscattering Mossbauer spectrometer prompted an investigation of the feasibility of resonant excitation of long-lived states in selected nuclei. Some of the nuclei under consideration, with their respective isomeric states given in brackets, include  $Sc^{45}$  (12.5 keV/0.3 sec),  $Nb^{93}$  (30 keV/13.6 yrs),  $Rh^{103}$  (40 keV/57 minutes), and  $Ag^{107}$  (93 keV/44 sec). A successful excitation of long-lived nuclear states is quite attractive because the widths of these supernarrow levels are comparable to the differences in gravitational potential energy arising from variation in the composition of the earth below, or surrounding, the source/absorber locations. Thus changes in the gravitational energy are detectable, in principle, on the basis of the observed changes in the absorption cross section of the Mossbauer photons. A discussion of the various factors that will affect the eventual success of the experiment will be presented.

CRITICAL FIELD MEASUREMENTS ON SUPERCONDUCTING FILMS AT 10 GHz USING A HIGH-Q SUPERCONDUCTING CAVITY. Gordon L. Spencer<sup>\*</sup> and B. S. Deaver, Jr. Department of Physics, University of Virginia, Charlottesville, Virginia 22901.

A frequency stabilized superconducting microwave cavity, operated in the  $TE_{011}$  mode, has been used to measure the temperature dependence of the surface impedance and the A.C. critical field of a thin tin film placed in the cavity. The complex conductivities obtained near the superconducting transition temperature of the film, are compared to the Mattis Bardeen theoretical results in the extreme anomalous limit. An unusual behavior of the imaginary part of the conductivity is found and may be evidence for non-linear effects. (Research supported by the National Science Foundation.)

GRAPH THEORY: SELECTED PROPERTIES OF TREES. Diane M. Spreser, Dept. of Mathematics, Madison College, Harrisonburg, Va. 22801

A graph  $G$  is a set  $\{V, X\}$  such that

- i.)  $V$  is a finite, nonempty set whose elements are called points, and
- ii.)  $X$  is a set of unordered, distinct pairs of points of  $V$ .

The elements of  $X$  are called lines of  $G$ . If  $V$  has  $p$  elements and  $X$  has  $q$  elements,  $G$  is called a  $(p, q)$  graph. A tree is a connected graph which has no cycles. A connected graph is unicyclic if and only if it has exactly one cycle.

Using a well-known theorem in the theory of trees, the following theorem (stated by Anderson and Harary) is proved in the paper:

Theorem: These statements are equivalent for any

$(p, q)$  graph  $G$ :

- i.)  $G$  is unicyclic.
- ii.)  $G$  is connected and  $p = q$ .
- iii.) There exists a line  $x$  of  $G$  such that  $G - x$  is a tree.
- iv.)  $G$  is connected and the set of lines of  $G$  which are not bridges forms a cycle.

The paper concludes with a discussion of tree partitions.

Throughout the paper, the condition  $p = q + 1$  is seen as a common thread which permeates important results in the theory of trees.

A COMPARISON OF SPECTRA FROM  $w$  ABSORPTION ON  $^{32}S$  AND  $^{40}Ca$  WITH STATISTICAL EVAPORATION CALCULATIONS. C. E. Stronach and C. M. Dennis<sup>\*</sup>, Dept. of Physics, Va. State Col., Petersburg, Va. 23803, W. J. Kossler<sup>\*</sup> and H. O. Funsten, Dept. of Physics, Col. of William and Mary, Williamsburg, Va. 23185. The prompt  $\gamma$  ray spectra from  $^{32}S$  and  $^{40}Ca$  targets taken in coincidence with stopped  $w$  from the SREL synchrocyclotron will be given. These will be compared with spectra obtained from the Blann-Plasil statistical evaporation code. The model of the absorption process contains an equilibrium term and a quasi-impulse approximation term. Equal ratios of these terms give good agreement with the gross features of the observed  $^{40}Ca$  spectrum, and fair agreement with the observed  $^{32}S$  spectrum. (Aided by NASA grant NGR 47-014-006)

1. The Space Radiation Effects Laboratory is supported by the NSF, NASA, and the Commonwealth of Virginia.

ELECTRICAL RESISTIVITY, THERMAL RESISTIVITY AND THE LORENTZ NUMBER IN IRON. G. R. Taylor. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

Electrical and thermal resistivity measurements on longitudinally saturated  $\langle 100 \rangle$  and  $\langle 111 \rangle$  iron crystals indicate that electron-electron scattering dominates electron transport in iron below 20°K. The measurements on the  $\langle 100 \rangle$  and  $\langle 111 \rangle$  saturated magnetization states were made in an applied longitudinal magnetic field of 250 Oe and 750 Oe, respectively; sufficient to saturate the iron crystals to a single domain along the measuring length as indicated by electrical and thermal hysteresis curves. The results from 4° - 20°K for the electron-electron scattering intrinsic electrical resistivity,  $\rho_i$ , thermal resistivity,  $W_i$ , and Lorentz number,  $L_i$  are:

For  $\langle 100 \rangle$  single domain iron in a 250 Oe field  
 $\rho_i = 20 \times 10^{-12} \Omega \cdot \text{cm}$ ,  $W_i = 22 \times 10^{-4} \text{ W} \cdot \text{cm}^2 / \text{ohm-deg}^2$ ,  $L_i = 0.98 \times 10^{-8} \text{ watt-ohm/deg}^2$

For  $\langle 111 \rangle$  single domain iron in a 750 Oe field  
 $\rho_i = 21 \times 10^{-12} \Omega \cdot \text{cm}$ ,  $W_i = 22 \times 10^{-4} \text{ W} \cdot \text{cm}^2 / \text{ohm-deg}^2$ ,  $L_i = 0.98 \times 10^{-8} \text{ watt-ohm/deg}^2$

The electron-electron scattering Lorentz number for iron provides additional support for predictions of a universal electron-electron scattering Lorentz number for the transition metals.

(Aided by grant from Madison College Program for Faculty Research and the Union Carbide Corporation.)



QUADRUPOLE MOMENT OF THE DEUTERON: EFFECT OF BARYON RESONANCES. H. T. Williams, D. P. Dempster<sup>a</sup>. Dept. of Physics Washington and Lee Univ., Lexington, Va. 24450

The formulation of an existing model of the deuteron, admitting baryon resonance admixtures, is used to calculate the deuteron quadrupole moment. The results are simply explained, and provide yet another constraint which must be met by a self-consistent presentation of the deuteron with the inclusion of excited states of the nucleon.

## Abstracts of Papers Section of Biology

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

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ZOOPLANKTON OF THE DISMAL SWAMP WATERS. K. B. Anderson\*, E. F. Benfield and A. L. Butkema, Jr., Dept. of Biology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Zooplankton samples and physical/chemical data were collected from 14 stations on a six-week schedule from September 1973 through November 1974. Seasonal and station variation was observed throughout the system over the year. General trends in water chemistry included lower dissolved oxygen with higher conductivity and nutrient content in the ditches as compared to the lake. Washington Ditch was the most unusual in comparison with other stations, particularly due to levels of calcium and pH.

Species identified and counted from the zooplankton collections included five copepods, 18 cladocera and 61 rotifers. *Tropocyclops prasinus* and *Mesocyclops edax* (copepods) were dominant in late summer and early fall. *Bosmina longirostris* and *Diaphanosoma leuchtenbergianum*, the major cladocera, both peaked in the spring. Most abundant rotifers included *Synchaeta longipes*, *Conochiloides dorsalis*, and *Polyzartha vulgaris*, all of which showed spring peaks. *Trichocera similis* and *Keratella cochlearis* were most common in the summer and *Microcerod clavus* was a winter form. The ditches generally showed higher diversity and greater variability in zooplankton communities and contained many littoral forms. Washington Ditch often produced alkaline-water forms such as species of *Brachionus* and *Filinia*.

(Funded in part by a grant from VAS)

Bio 1

ENERGETIC EFFICIENCY OF BIRDS. C. R. Blum. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23284

Multiple regression analyses were made of an extensive set ( $N = 531$ ) of measurements of the existence energy of House Sparrows, *Passer domesticus*, collected both winter and summer from twelve widely separated locations in North America. Sparrows were tested in a factorial experiment involving five different foods presented under three photoperiodic regimes and a wide range of ambient temperature. Energetic efficiency (existence energy/energy intake  $\times 100$ ) is significantly affected by protein, carbohydrate and fat content of the food provided. When all recognized independent variables (twelve in all) were considered, protein content of food was found to be the most important factor in the prediction of efficiency of energy utilization. Other significant variables, in order of importance as judged by standard partial regression coefficients, are fat content of food, ambient temperature, location from which birds were collected, photoperiod, weight change and season.

Bio 3

CYTONEUTIC ANALYSES OF LYMPHOCYTE CULTURES AFTER EXPOSURE TO CALCIUM CYCLAMATE. Boone, Carolyn, R.M. Knight, C.A. Jordan, and E.W. Jemison. Dept. of Life Sciences, Va. State College, Petersburg, Va. 23803

Chemically induced chromosomal aberrations, especially breaks, polyploidy, and aneuploidy were constantly observed after 5 or 20 hours incubation in  $10^{-4}$ ,  $10^{-3}$ , and  $10^{-4}$  molar concentrations of calcium cyclohexyl-sulfamate. The lymphocyte cultures were prepared from peripheral blood of humans. Giemsa staining produced banding patterns for microscopic observations and karyotyping. Fluorochromes, quinacrine mustard and acridine orange produced variable patterns of fluorescence. Significant differences were noted when the metaphase chromosomes of lymphocytes treated with the varying concentrations of calcium cyclamate were compared with the control. (Supported by Minority Biomedical Support Program)

Bio 5

EFFECTS OF CONTINUOUS LIGHT ON RETINAL STRUCTURE IN TROGLOBITIC AND EPIGEAN SALAMANDERS. Joseph C. Beharese, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va.

The eyes of the Ozark cave salamander, *Typhlotriton spelaeus*, develop and become functional in larvae. Blindness in transformed adults results from degeneration of visual cells and pigment epithelium. To determine if retinal degeneration is influenced by light, larvae were induced to transform and were maintained in continuous light (238-292 lux) or darkness for 111 to 366 days. Nineteen of 32 D-animals showed retinal degeneration like that observed in field-collected adults, whereas only three of 36 L-animals showed such degeneration. Eleven L-animals, however, had retracted apical processes of the pigment epithelium with normal or fragmented visual cells; free, pigmented cells were frequently observed in the space between sensory retina and pigment epithelium. Unlike retinal degeneration in darkness, these modifications were limited to the ventral retinal field. The failure to find such a "light effect" in *Eurycea longicauda* under similar conditions or in adult *Plethodon cinereus* under conditions where intensity of illumination was doubled indicates that the effect is unique to the eyes of *T. spelaeus*. These modifications of the retina in animals kept in continuous light probably represent an interaction between the effects of light and some inherent feature of the retinal degeneration process. (Aided in part by a grant from the Old Dominion University Res. Fdn.)

Bio 2

THE EFFECT OF AFLATOXIN B<sub>1</sub> ON CROSSING-OVER IN *Drosophila melanogaster*. M. A. Booker\*, J. P. Chinnici, G. C. Lewellyn, Dept. of Biology, Virginia Commonwealth Univ., Richmond, Va. 23284

The effects of Aflatoxin B<sub>1</sub>, a fungal metabolite known to be carcinogenic in mammals, on viability, developmental time, sex ratio, fecundity and crossing-over in the X chromosome of *Drosophila melanogaster* were studied. Female flies homozygous for 4 sex-linked recessive genes (scute bristles, crossveinless wings, singed bristles and miniature wings) were mated with wild type males. Resultant eggs were placed in 8 dram vials containing synthetic medium supplemented with either 1.5 ppm Aflatoxin B<sub>1</sub> (experimental) or no Aflatoxin (controls). F<sub>1</sub> eggs which enclosed were examined and virgin females were saved for further crosses. These crosses involved mating heterozygous F<sub>1</sub> females, which developed on either experimental or control media, with mutant males from stock bottles and determining from the offspring of the F<sub>1</sub> crosses, the cross-over values for the 3 regions of the X chromosome. The F<sub>2</sub> generation developed on control media.

Results of these studies showed the following: Aflatoxin B<sub>1</sub> has a significant effect on: (1) reducing the length of female flies grown on experimental media; (2) decreasing egg-adult viability in general and (3) having a more deleterious effect on males in particular. Crosses involving the F<sub>1</sub> females showed that being raised on aflatoxin media (1) significantly decreased fecundity; (2) has no effect on the sex ratio of offspring produced and (3) has no effect on crossing-over in any of the 3 chromosomal regions studied. Bio 4

A STUDY TO DETERMINE THE NUMBER OF ORGANISMS REQUIRED PER SAMPLE TO ACCURATELY MEASURE THE SEQUENTIAL COMPARISON INDEX AND THE PATRICK HENRY COMMUNITY COLLEGE MODIFICATION OF THAT METHOD. John F. Bryant, Robert P. Osborne, Steven D. Mason, Donald B. Minter, and James W. McIntosh, Jr. Dept. of Biology, Patrick Henry County, Col., Martinsville, Va. 24112

Samples of macroinvertebrate benthic fauna were taken with the Surber sq. ft. sampler between Jan. and March 1975 from selected sites on the upper Smith River and Rock Castle Creek in Patrick County, Va. Each collection consisted of five (5) two sq. ft. samples of each site.

Two diversity indices were computed for each sample: The Cairns Sequential Comparison Index and the Patrick Henry College modification of the Cairns SCI. It was found that the mean difference between the two was 9.2%.

A comparison between the diversities of large (up to 400 specimens) and small (less than 200 specimens) samples was also made. Modified diversity indices were computed for individual and combined samples of the same collections. With individual sample size varying up to 400 organisms, the mean fluctuation of the diversity was 4.6%. This indicates that a reliable diversity index can be obtained from the modified method using samples of less than 200 specimens.

THE EFFECT OF THE LENGTH OF THE INDUCTION PERIOD ON THE INDUCIBLE ENZYME O-PYROCATECHUIC ACID CARBOXYLASE IN AGING CULTURES OF *ASPERGILLUS ORNATUS* (RAPER). L. M. Cleary\*, and B. W. Courson\*, Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

After 6 hours of induction by 0.1% L-typtophan, 168 hour cultures of both sporulating and non-sporulating mycelia of *Aspergillus ornatus* showed a percent induced activity of opca carboxylase which was less than one fifth of the activity in 96 hour cultures. The effect of the length of the induction time on 168 hour cultures was investigated by assaying for enzyme activity after 3, 6, 9, 12, and 24 hrs. of induction. The percent induced activity after 3, 9, 12, and 24 hours of induction was significantly increased over the activity after 6 hours of induction, but never to more than a third of the activity in 96 hr cultures after 6 hrs. of induction. Absolute values of basal and induced enzyme activity showed significant cyclic fluctuation correlated with length of the induction, suggesting an endogenous rhythm in opca carboxylase in *A. ornatus*. Cellular aging is a plausible cause of loss of molecular control exhibited by partial loss in ability to induce the enzyme at 168 hours regardless of the length of the induction time.

Bio 7

ULTRAVIOLET ABSORPTION BANDS OF DIPEPTIDES AND PROTEINS IN BLOOD PLASMA OF SOME ANIMALS INCLUDING HUMANS. G. Colanano. Dept. of Vet. Sci., VPI & SU, Blacksburg, Va. 24061.

The characteristic absorbance of blood plasma protein at 280 nm was related to its dipeptide chromophore band at 190-205 nm. All dilutions were performed with distilled water starting with 0.1 ml of blood plasma transferred with graduated pipettes to volumetric flasks, at 20±1°C, and were read in a quartz cell. Human blood plasma, as well as that of pig, rat, rabbit, chicken, and quail was diluted 1:50 and the 280 nm peak, with its decreasing slope at 260 nm, was used for the determination of the protein concentration. This was estimated directly at the 280 nm peak, with an absorbance of 1.0 for approximately 1.0 mg of protein per ml of solution. A 1.45 absorbance at 280 nm, minus 0.74 absorbance at 260 nm, gave the mg of protein per ml of solution (Kalkar, M., J. Biol. Chem. 167:461, 1947), and was used on a 1:100 dilution for greater precision on concentrations below one gram per liter. For a 1:5000 dilution the 190-205 nm band had an approximate absorbance of one. In different animals the 194 nm peak position, found in man, shifted toward lower or higher wavelengths with differences in shoulders on both sides of the peak. The level of protein synthesis and catabolic breakdown within the 195 nm dipeptide bond, when related to the actual concentration of protein at 280-260 nm in blood plasma, has practical clinical applications. Any pressure on the homeostatic mechanism, as controlled by the circulatory system, may be detected in time to permit early control of blood dyscrasia.

Bio 8

STUDIES ON THE TOOTH PLATES OF THE AFRICAN LUNG FISH, *PROTOPTERUS*. E. B. Conant and H. Meaders\*, Dept. of Biology, Mary Baldwin College, Staunton, Va. 24401

Twenty-one jaws were collected from lungfish ranging in size from 73 grams to 15 kilograms. Approximately forty parameters were measured, and then the jaws were studied by various means to determine the mode of growth and wear.

The tooth plates, characterized by three tooth rows, are actually extensions of the jaw bones themselves, covered by enamel or enamel-like dentine. They undergo continuous growth by the addition of cusps and other material. The anterior tooth row tends to remain conical in shape and is sharp to a point; the median tooth row grows laterally to some extent, and in larger fish has a blade-like biting surface; the posterior tooth row shows the greatest lateral growth and also bears a shearing edge. Cusps are characteristically found at the lateral end of the posterior tooth row (in the living fish, below the gum line), and are sometimes found basally and laterally on the median tooth row, each cusp being associated with a layer of enamel that is laid down successively. The growth rate of each tooth row is quite regular, although the growth rate between the various tooth rows does differ. Tooth plates from smaller fish tend to have a flattened crushing surface, those from larger fish show a shearing configuration. As the valleys deepen between the tooth rows, the jaws nest more completely on each other. In tooth plates larger than one inch across, there is the development of a "locking peg" behind the anterior tooth row such that occlusion is rendered more precise.

Bio 9

THE INFLUENCE OF DISPLACEMENT DISTANCE AND VISION ON THE HOMING BEHAVIOR OF THE WHITE-FOOTED MOUSE (*PEROMYSCUS LEUCOPUS NOBILORACENSIS*). Judith A. Cooke\* and C. Richard Termon, Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

The purpose of this experiment was to determine the degree to which white-footed mice would home when displaced, the effect distance had upon homing, and whether vision was involved to a significant degree in the process of return. Mice were removed from two study areas during eight night trapping periods and then released at three different release points. Homing was measured by live-trapping during seven nights subsequent to release. Ten replications were conducted over six months.

Mice were capable of returning to their home plots with greater frequency than expected by random wandering when released midway between study areas (336 meters). When released on the study plot opposite from that of capture (671 meters), homing performance was not significantly different than expected by chance. Homing success appeared to be distance dependent and influenced by the habitat where release occurred.

The homing success of blinded mice released on their home plots was not significantly different than that of intact mice. However, a significantly smaller proportion of blinded mice than intact mice homed when released midway between plots. The differential response to loss of vision will be discussed.

Bio 10

THE RELATIVE EFFECTIVENESS OF TWO SIZES OF SHERMAN LIVE TRAPS IN CAPTURING *PEROMYSCUS*. P. L. Daiby and D. O. Straney. Dept. of Biology, VPI&SU Blacksburg, Va. 24061, and Savannah River Ecology Laboratory, Aiken, S.C. 29801

A need to choose the most effective trap type is critical to most small mammal population studies. This trapping study was conducted to determine the relative effectiveness of the small and large Sherman live traps, and to compare the results of both with that of the Museum Special snap trap, known for its effectiveness.

A total of 3018 trap nights were accumulated in the woodlands surrounding Blacksburg during the winter months of 1974-1975. A total of 227 small mammals were captured, of which 219 were *Peromyscus leucopus*. Trapping results show that the small Sherman traps captured 104 *P. leucopus* while the large Sherman traps captured only 6 individuals. This is in contrast to a California study which demonstrated that the larger traps were more effective than the smaller traps in capturing similar-sized (20-25g) *Peromyscus*. The Museum Special snap traps captured 108 *P. leucopus*, indicating that it and the small Sherman live trap are equally effective.

Bio 11

THE EFFECT OF DIETARY SeleniUM ON IRON METABOLISM IN THE MONGOLIAN GERBIL, *Meriones uingulatus*. B. F. Edmundson\*, J. C. Nolte\*, D. J. Rice\*, R. V. Brown, G. C. Llewellyn and J. H. Lalor, Dept. of Biology, Va. Commonwealth University, Richmond, Va. 23284

Selenium has been found to be an essential trace element in most animal diets. Gerbils from our own stock colony were divided into two major groups on an age-weight basis and each group was further divided into subgroups receiving either 0.0 ppm, 2.5 ppm or 5.0 ppm Selenium as Sodium Selenite in the drinking water. As a supplement to the Selenium experiment, all juvenile and three gerbils from each adult group were intubated with <sup>59</sup>Fe++ as Ferrous Citrate to investigate Iron uptake and metabolism. Whole body counts for Iron were taken on all intubated gerbils.

Both experimental adult groups showed an increased growth rate and a decreased drinking rate. The juveniles showed little difference in growth rate but showed a reduced drinking rate. Iron uptake was shown to be greater in the 2.5 ppm juveniles than in the 5.0 ppm juveniles; both were greater than in the control juveniles. In the adult gerbils, the Iron uptake decreased with increasing Selenium concentration.

Special attention will be given to suspected target organs for Selenium toxicity. This will be correlated further with histopathology and blood data.

Bio 12

A COMPARATIVE SURVEY OF THE MACROINVERTEBRATE BENTHIC FAUNA USING THE SEQUENTIAL COMPARISON INDEX (PWC MODIFICATION) ON SMITH RIVER AND ROCK CASTLE CREEK. W. Logan Esarey, Jr., Jennifer S. Lowe, Darryl L. Martin, Robert P. Osborne, Donald R. Strachan, Jr., Donald B. Minter, and James W. McIntosh, Jr. Dept. of Biology, Patrick Henry County, Col., Martinsville, Va. 24112

Twelve monthly collections of macroinvertebrate benthic fauna were made in the head waters of Smith River and its main tributary, Rock Castle Creek in Patrick County, Va. Six sampling stations were established on each stream. Shifts in densities were noted and diversity indices were calculated using the Sequential Comparison Index method (Cairns, et. al.) for each station each month.

A t-test on the mean monthly SCI indicates that at the .10 level of confidence the variances of the two streams show no significant difference. The correlation coefficient was 0.71. The mean density of organisms per sq. ft. ( $929.0 \text{ cm}^2$ ) was greater in the Smith River than in the Rock Castle Creek ten of the twelve months. There were three peaks in density which occurred simultaneously in Nov. (1973), May and Aug. (1974). However, the mean SCI was higher in RC Creek than in Smith River nine of the twelve months. The mean SCI for both streams reached a low between April and May when the Mayflies constituted over 75% of the organisms sampled. The mean SCI reached a high in Aug. for both streams when no order of organisms composed more than 33% of the total samples for each stream.

Bio 13

A MODIFICATION OF THE SEQUENTIAL COMPARISON INDEX IN MACROINVERTEBRATE BENTHIC FAUNA STUDIES. W. Logan Esarey, Jr., Jennifer S. Lowe, Darryl L. Martin, Robert P. Osborne, Donald R. Strachan, Jr., Donald B. Minter, and James W. McIntosh, Jr. Dept. of Biology, Patrick Henry County, College, Martinsville, Va. 24112

The PWC modification for determining the diversity index is as follows: (1) The macroinvertebrates are grouped and counted. They are grouped or classified roughly to Families. All identification is by gross morphology, with no keying necessary. A dissecting scope is helpful, if the invertebrates are small. (2) A letter is assigned to each group. (3) A reading in sequence of the Random Number Table is made. Each time a number falling in a letter group is encountered, the letter is recorded in the order encountered. (4) The number of "runs" is determined by a count of the number of times a letter different from the previous one is encountered, when the letters are examined in the same sequence as recorded. (5) The diversity index is calculated by dividing the number of "runs" by the total number of organisms.

Bio 14

FOOD HABITS OF PINE VOLES IN TWO VIRGINIA APPLE ORCHARDS. J. E. Estep\*, D. J. Cengel\*, R. E. Noffsinger\*, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sci., VPI&SU, Blacksburg, Virginia 24061.

Pine voles (*Microtus pinetorum*) were trapped in a maintained and an abandoned apple orchard in Rappahannock Co., Virginia. Voles were collected bimonthly between July 1972 and May 1973. Stomach contents of 110 adult voles were examined microscopically. In both orchards, above ground parts of grasses and forbs comprised over 84% of the identified epidermal fragments (IEF) in the stomachs from all months. Significantly ( $P < 0.01$ ) more grasses were consumed in the maintained orchard than in the abandoned orchard (55.0% IEF and 35.7% IEF, respectively). Significantly ( $P < 0.01$ ) more forbs were consumed in the abandoned orchard (77.3% IEF) than in the maintained orchard (36.4% IEF). It appeared that forbs were preferred during spring and summer and that grasses were preferred during fall and winter. Total root consumption was greatest in both the maintained and abandoned orchard during January (7.6% IEF and 8.0% IEF, respectively) and March (8.2% IEF and 14.7% IEF, respectively). Small numbers of apple root fragments were identified in stomachs collected during March (3.2% IEF) in the maintained orchard and during January (0.7% IEF) and March (0.4% IEF) in the abandoned orchard. Voles collected in the maintained orchard contained significantly ( $P < 0.05$ ) more fragments of apple fruit than voles from the abandoned orchard. (Supported by the U.S. Fish and Wildlife Service).

Bio 15

THE OCELLI AND ORIENTATION IN THE FLESHFLY, *SARCOPHAGA BULLATA*. Gisela K. Fashing\*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The simple eyes or ocelli of insects generally occur in a group of three between the compound eyes. Despite the presence of ocelli in many insect species, their function remains a mystery. Two functions are generally suggested - photokinesis and phototaxis. The latter phenomenon was investigated in the fleshfly, *Sarcophaga bullata*, with the following results: 1.) On a horizontal surface ( $0^\circ$ ), ocellar occlusion does not alter the flies' orientation toward a horizontal light source. 2.) If the fly is on a vertical surface ( $90^\circ$ ) while presented with a horizontal light source, ocellar occlusion causes decreased orientation to light. This decrease in the strength of phototaxis is more pronounced the brighter the light. 3.) Flies tested on a surface inclined at  $5^\circ$  above the horizontal also show no change in orientation after ocellar occlusion. 4.) On a surface inclined at  $30^\circ$ , flies demonstrate a significant decrease in phototactic accuracy, but it is not as pronounced as at  $90^\circ$ . Therefore, the compound eyes alone are sufficient for phototactic orientation on horizontal surfaces, but on inclined surfaces, the ocelli are involved in light responses.

Bio 17

SOME EFFECTS OF CRUDE MARIHUANA EXTRACT AND MARIHUANA SMOKE EXTRACT ON FEEDING BEHAVIOR OF THE LABORATORY MOUSE. J. E. Ezell. Div. of Math and Natural Sciences, J. Sargeant Reynolds County, Col., Richmond, Va. 23230

Changes in appetite caused by marihuana were investigated through oral administration of crude and smoke extracts of marihuana to laboratory mice.

Male mice of approximately the same age and size were given daily oral doses of the extracts and maintained in metabolism cages where food consumption was monitored.

After two days of treatment, those mice treated with the crude extract showed a statistically significant drop in food consumption compared to those treated with smoke extract and the controls (non-treated). By day three the groups treated with crude extract recovered to a level that, along with the groups treated with smoke extract, was slightly above that of the control groups. Treatment continued for a total of five days.

Bio 16

QUANTIFICATION OF PATTERN DISCRIMINATION IN THE HONEYBEE. Norman J. Fashing. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Much research has been conducted on form perception in honeybees since von Frisch first discovered the ability in 1914. In general, bees are trained to a specific pattern by classical conditioning, and then tested by offering a choice of two patterns (one more similar to the training pattern than the other) and quantifying the responses to each pattern.

Previous researchers trained bees to a pattern at a feeding station using food as a reward, but this is time consuming since individual bees have to be marked and their visitations recorded to determine when they have learned the training pattern. Our method utilizes the fact that returning foragers find the exact locality of the hive entrance by recognizing certain features surrounding it. The apparatus consists of a circular training pattern attached to the front of a white  $7' \times 4'$  board. The hive is located behind the board and bees enter and exit through the center of the pattern. All foragers learn the pattern as they make their orientation flight before leaving the hive vicinity, essentially "training" themselves. During a test, the hive entrance is plugged and the training pattern replaced by the two test patterns, each spaced equidistant from the hidden nest entrance. The test patterns open into false nest entrances which in turn enter into funnels on the back of the board. The choice is quantified by counting the bees as they exit the funnels into a collecting cage. This method is faster and in many ways superior to the feeding station method.

Bio 18

THE EFFECTS OF AN INTERSTATE HIGHWAY UPON MOVEMENT PATTERNS OF SMALL RODENTS. Michael H. Gerardi\* and J. Elwood Fisher, Dept. of Biol., Madison College, Harrisonburg, Va. 22801.

Studies between May, 1973 and February, 1974 on the effects of an interstate highway system upon the movement patterns of representatives of *Peromyscus maniculatus* and *Reithrodontomys humilis* which inhabit areas immediately paralleling these roads suggest that these rodents (1) rarely transverse the highway; (2) do so only during periods of population stress; (3) use avenues whereby they avoid direct contact with the road surface, such as drainage pipes and overpass girders; and (4) develop a home range which does not overlap the highway. Furthermore, more males cross than females, likely because they have a more extended movement pattern. The median strip does not appear to harbor a native population; however, amount and type of vegetation in the median may have some effect on movement to and from the median.

Bio 19

LEAD LEVELS IN VEGETATION AND SOILS NEAR HIGHWAYS OF VARIOUS TRAFFIC DENSITIES. C. D. Goldsmith Jr.\*, and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ. Blacksburg, Va. 24061

Soil and vegetation samples were taken at distances of 3m, 6m, 12m and 18m from four highways of various traffic densities. Traffic densities were (A) 23,000 vehicles/day (B) 9,000 vehicles per day (C) 1,000 vehicles/day and (D) an intersection with 12,000 vehicles/day on each route. Samples were assayed for lead using an atomic absorption spectrophotometer. Lead concentrations (ug/g) in soil ranged from 87.3 at 6m to 47.4 at 18m (Area A) and from 22.4 at 3m to 27.5 at 18m (Area C). Soil lead levels tended to increase with traffic density and to decline as distance from the highway increased. Mean plant lead levels (ug/g) ranged from 69.9 at 6m to 29.0 at 18m (Area A) and from 22.4 at 3m to 15.0 at 18m (Area C). Lead levels in vegetation tended to be highest where traffic density was highest and tended to decline as distance from the highway increased.

Bio 20

THE GROWTH OF MYCELIAL MATS OF *ASPERGILLUS ORNATUS* (RAPER) ON LIQUID CULTURE. R. T. Goodwin\*, and B. W. Coursen\*. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

The activity of the enzyme, o-pyrocatechic acid carboxylase was measured in mycelial mats of *Aspergillus ornatus* after a single induction with tryptophan in an attempt to correlate changes in the induction of this enzyme with the age of the organism. Changes in the pH and glucose concentration of the liquid growth medium were measured throughout the experiment. Measurements of the dry weight, total DNA content, and total protein of the mycelial mats were also made to correlate changes in these growth parameters with the induction of the enzyme. No significant changes in the external environment of the organism were evident after 16 days. Growth continued linearly throughout the experiment, but induction of the enzyme was lost after 5 days. In 10-day old mats the basal level increased, but at 15 days both the basal and induced levels of the enzyme were extremely low.

Bio 21

GROSS MORPHOLOGY OF THE REPRODUCTIVE TRACT OF THE TROPICAL CLIMBING RAT *TYLONYX NUDICAUDUS*. J. R. Haas, P. L. Dalby, and P. F. Scanlon, Depts. of Biology and Fisheries and Wildlife, VPI & SU, Blacksburg, Va. 24061.

The tropical climbing rat is unique because of its tractability, unusual behavioral and morphological adaptations for an arboreal existence, and because of certain peculiar reproductive features. Gross morphology of the female reproductive tract is described and compared with that of the laboratory rat, *Rattus norvegicus*, and several genera related to *Tylomys*. The following measurements and observations were taken from the female climbing rats: ovarian dimensions, number and size of corpora lutea, uterine horn length, cervical length, vaginal length, and urethral length. Of most interest is the length of the urethra, nearly comparable to that of the male, and also the high number (10-29) of well-developed corpora lutea present in the ovaries.

Bio 22

FACTORS AFFECTING THE QUALITY OF THE RECREATIONAL ANGLING EXPERIENCE. Ed L. Hampton and Robert T. Lackey, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Fisheries managers have long operated under the assumptions that pounds or numbers of fish caught (MSY) or time spent fishing (angler-days) were accurate measures of fisheries output. However, many fisheries scientists today advocate development of a multidimensional output measure which would incorporate social, aesthetic, and psychological factors. The present study was undertaken to delineate and determine the relative importance of ten items affecting the quality of angling as perceived by Virginia fee-fishermen. A self-administered questionnaire employing a modified Likert scale was used to evaluate the ten quality-related items. A factor analysis was run which resulted in 4 factors relating to the quality of fee-fishing. The factors were attractiveness of the fishing site, amount of fishing, satisfaction, and improvements needed. The 4 factors, when combined with the mean importance scores, indicate that the quality of fee-fishing is multidimensional and not dependent solely on catch. These findings, coupled with similar studies, indicate that fisheries managers need to reexamine their historical objectives and begin considering fisheries output in terms other than MSY and angler-days. (Supported by the United States Department of Agriculture)

Bio 23

GLYCOGEN METABOLISM DURING DIFFERENTIATION OF *DICTYOSTELIUM DISCOIDEUM*. J. F. Harris and C. L. Rutherford. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

In our laboratory an ultramicrochemical technique is employed to assay tissue samples of the various cell types in a single organism at the developmental stage of interest. The technique utilizes tissue samples of 0.1 ug. dry weight and reaction volumes of 0.1 ul. Enzyme and substrate levels are amplified by a method of enzymatic cycling employing pyridine nucleotides. Our current studies of glycogen turnover and conversion to cell wall material, as related to differentiation, indicate a decrease in glycogen synthetase activity from tip to base of the developing stalk. The requirement for soluble glycogen, as a primer, decreases during development of spore cells. The data suggest a change, from soluble glycogen primer dependent glycogen synthetase and soluble product, to soluble glycogen primer independent enzyme activity and insoluble product formation during development. We observe a 20-fold increase in the specific activity of the degradative enzyme, glycogen phosphorylase, as the organism develops from myxamoeba to culmination with a corresponding decrease from culmination to sorocarp. Assays of specific cell types show an increasing phosphorylase activity as pre-stalk cells migrate into the apex of the developing culmination. In sorocarp the activity is low in all sections of the stalk. At sorocarp both cell types have low phosphorylase activity.

Bio 24

THE EFFECT OF FOX CONTROL ON RODENT POPULATIONS. Michael S. Hensley and J. Elwood Fisher, Dept. of Biol., Madison College, Hbg., Va. 22801.

A 16-month study of the effects of fox control on a woodmouse population was initiated in August, 1972, in Rockingham County, Virginia. Two woodlot sites which joined poultry farms were selected as study areas. One farm, designated as the Control Area, supported a heavy, relatively undisturbed fox population consisting largely of gray foxes. On the other farm, termed the Experimental Area, heavy fox trapping was maintained regularly throughout the period to insure a habitat relatively free of foxes. Rodents were live-trapped at two-month intervals while dropping boards were maintained during the study to gain additional data.

After four months of inventory the woodmouse population on the Experimental Area showed a significantly sharp decline and a greater percentage of mice were subadults; turnover rate increased; life expectancy decreased; and sex ratios shifted toward more females. Furthermore, both sexes remained in reproductive condition year round, while seasonal reproductivity characterized individuals on the Control Area.

With the control of foxes the New York weasel (and possibly other predator) maintained a heavy stress on the woodmouse population. The woodmouse-gray fox relationship appears to be indirectly density-dependent; with the weasel as the major interfering species. Bto 25

TULAREMIA: ITS POSSIBLE ROLE IN REGULATION OF COTTONTAIL RABBIT POPULATIONS IN VIRGINIA. B. A. Jacobson\*, R. L. Kirkpatrick, and B. S. McGuinness\*, Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061.

An examination of cottontail rabbit (*Sylvilagus floridanus*) population indices recorded from 1956-1974 at two Virginia military bases, Fort Pickett and Fort A.P. Hill, revealed that an abrupt decline in rabbit numbers occurred in 1961. Tularemia was found in rabbits trapped at Fort Pickett during the decline. Since the 1961 decline, hunter harvest of rabbits at these locations has remained at approximately one-third of the pre 1961 harvest levels. From Sept., 1973 to Oct., 1974, five seasonal sections totaling 201 rabbits were made from two Virginia localities, Fort Pickett and the Radford Army Ammunition Plant. Approximately 20 rabbits were collected from each location during each season. Serum from these rabbits was tested by the Commonwealth of Virginia's Division of Consolidated Laboratory Services for the presence of antibodies to tularemia antigen. Four of 17 Fort Pickett rabbits and 1 of 18 Radford rabbits collected during Sept. 73 had positive cube agglutination titers (range 1:5 to 1:20). Detectable titers were not present in the remaining four seasonal collections. Although positive antibody titers were not obtained in 1974, hunter harvest of rabbits at Fort Pickett during 1974 was the lowest ever recorded. Although not conclusive, these results suggest tularemia was a factor in the 1961 population decline and that it may have continued as the primary limiting factor of the population. Bto 27

TREHALOSE METABOLISM DURING DIFFERENTIATION OF *DICTYOSTELIUM DISCOIDEUM*. B. L. Jefferson and C. L. Rutherford. Dept. of Biology, VPI&SU, Blacksburg, Va. 24061.

Trehalose-6-P synthetase catalyzes the enzymatic synthesis of trehalose. During the 24 hour developmental cycle there is no detectable activity of this enzyme before 3 hours, a linear increase in specific activity from 5 to 20 hours, and then a rapid disappearance of activity. Spore and stalk cells have activity at the culmination stage. A decreasing gradient of activity is evident from the top to the bottom of the stalk.

Trehalose first appears 18 hours into the cycle and accumulates during sorocarp construction. Trehalose is located in the spores and in a decreasing gradient from the top to the bottom of the stalk.

The degradation of trehalose into glucose is catalyzed by trehalase. An assay of whole organisms shows high activity of trehalase in the early stages of development, a decline which reaches the lowest point at 14 hours, and an increase with maximum activity being attained again by 24 hours. At the sorocarp stage, spore cells and pre-stalk cells show equal activity. A dramatic 10-fold increase in activity is seen from top to bottom of the stalk.

This study employs ultramicrochemical techniques and enzymatic cycling to assess the presence of cell specific biochemical events. A 0.02 µg. section of one individual is used in a reaction mixture of 0.1 µl.

Bto 29

USE OF ARTIFICIAL SUBSTRATE FOR SAMPLING MACROINVERTEBRATE ORGANISMS. Franklin L. Jarrett, Kay B. Grogan, Darryl L. Martin, and James W. McIntosh, Jr. Dept. of Biology, Patrick Henry County, Col., Martinsville, Va. 24112.

Two types of artificial substrates were used in the Smith River and the Rock Castle Creek in Patrick County, Va., to determine an easier and more efficient way of sampling. The first sampler is a 3 inch cube made of 1/2 inch hardware cloth with a nylon scrub pad on the inside. The second sampler is made of eight wooden plates 3 x 3 and a quarter inch thick. The plates are stacked with a quarter inch space between each, and held together with an eyebolt.

The samplers were placed in selected sites on the Smith River and Rock Castle Creek for a period of 4 weeks. At the end of this period they were removed. The diversities were determined and compared with diversities taken at the same site a year before, using the Surber sampling method. Our findings showed that the wire cubes were the most efficient.

Bto 26

BOTFLY (*Cuterebra buccata*) PARASITISM OF THE COTTONTAIL RABBIT IN VIRGINIA. B. A. Jacobson\* and B. S. McGuinness\*, Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, Va. 24061.

Between the years 1949-1974, 2586 cottontail rabbits (*Sylvilagus floridanus*) were collected in Virginia and examined for signs of myiasis. Of this number, 24.4% were infected with or had emergence scars from botfly larvae (*Cuterebra* sp.). Eighteen flies reared from third instar larvae were identified as *Cuterebra buccata*. Several host parasite relationships were recorded. The number of rabbits examined for each relationship is indicated in parentheses. Male (649) and female (602) rabbits were infected about equally, 28.8% and 30.1%, respectively. Incidence of infection for juvenile rabbits (307) was almost twice that of adult rabbits (358), 28.0% and 14.5%, respectively. Juveniles (108) also carried more larvae per host than did the adults (58), means of 2.14 and 1.62, respectively. Locations of larval development sites were recorded for 440 larvae. Of these, 46.4% were in the genital region, 36.1% were in the side or shoulder regions, 8.6% were in the neck or face region, 8.2% were in the back region, and 0.7% were in other regions on the host. Composite monthly incidence of infection recorded over a several year period was as follows: Jan. (33), 3%; Feb. (25), 0%; Mar. (48), 0%; Apr. (18), 0%; May (no rabbits collected); Jun. (42), 17%; Jul. (100), 28%; Aug. (67), 27%; Sep. (162), 29%; Oct. (194), 24%; Nov. (190), 23%; Dec. (49), 12%. Bto 28

COCCON PRODUCTION IN HEADS AND TAILS OF *DUGESIA DOROTOCEPHALA* OF VARIOUS AGES FOLLOWING REGENERATION AFTER TRANSVERSE SECTION. Marie M. Jenkins, Dept. of Biol., Madison Col., Harrisonburg, Va. 22801.

Four groups of sexually mature *Dugesia dorotocephala* aged, chronologically, 3, 24, 1, and 4 years, were divided into two subgroups each, and animals in one subgroup in each category were cut in two between mouth and gonopore. Twelve groups thus obtained (3W, 3H, 3T = whole worms, heads, and tails 3 years old; etc.) consisted of 50 worms each. Three months were allowed for regeneration, then cocoons and offspring were collected and counted for one year. Data were subjected to statistical analysis by means of Student's "t" test.

Older planarians compared with .5W showed a significant decline in cocoon production which varied from the .05 to .01 level in heads and tails of one- and 24-year-olds to .001 in 3W. In heads and tails grouped together reduced cocoon deposition was significant in both 1H + 1T and 2.5H + 2.5T beyond the .05 level, but was highly significant in 3H + 3T. Offspring produced followed similar trends.

Results of this experiment show that regeneration of cut heads and tails induced some degree of rejuvenation but the effect diminishes with increasing age, and support the earlier finding that true senescence occurs in sexually mature *Dugesia dorotocephala*.

Bto 30

APPROACHES TO MODELING THE DYNAMICS OF LARGE MOUTH BASS POPULATIONS. Douglas B. Jester, Jr. and Robert T. Lackey, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Large-mouth bass fisheries are very complex and poorly understood systems. They are found in diverse habitats and diverse communities and are exploited by a diverse community of anglers. Modeling provides a means of coping with this complexity, evaluating alternative management strategies, identifying needed research, and formalizing knowledge about bass populations. A strategy for constructing a general, but realistic and accurate model of the dynamics of large-mouth bass populations is proposed. (Supported by the Bass Research Foundation)

B10 31

VIRULENCE OF *NAEGLERIA FOWLERI* STRAINS FOR MICE. D.T. John and S.L. Josephson.\* Dept. Microbiology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298.

Ten years ago in Australia, Fowler and Carter described a fatal human disease, now known as primary amebic meningoencephalitis caused by *Naegleria fowleri*, a free-living ameba. To date, about sixty cases have been reported world-wide, of which only one has survived. This study presents the results of the relative virulence for mice of six strains of *N. fowleri*: two from Australia (NP66 and NP69) and four from the Medical College of Virginia (CJ, LEE, TY, and WM).

Male BALB/c mice weighing 19 to 24 g were inoculated intranasally with  $5 \times 10^4$  amebae per mouse. Ten mice were used to test each strain of *N. fowleri*. Mortality among the mice inoculated with the Australian strains was 20% for NP66 and 100% for NP69; the days on which the animals died were 13 and 9-11 respectively. Mortality was 10% for both the WM and CJ strains. Mice died on day 11 and day 17. Sixty percent mortality occurred among mice receiving LEE and TY strains. The deaths occurred between days 11-19 for the LEE strain and days 14-20 for TY. Further studies showed that following serial passage in mice, the virulence of the LEE strain increased from 60% to 100% mortality and the days on which deaths occurred narrowed from 11-19 to 8-10. These data indicate that although the six strains of *N. fowleri* were isolated from fatal human cases, the parasites showed varying degrees of virulence for mice.

B10 32

IN VITRO GROWTH OF *NAEGLERIA FOWLERI*. S.L. Josephson\* and D.T. John. Dept. of Microbiology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298.

The growth of *Naegleria fowleri* (LEE strain) in various axenic media was studied together with a general analysis of the growth characteristics of two *N. fowleri* strains (LEE and NP66) isolated from two amebic meningoencephalitis victims.

After examining the change in cell number with time using the LEE strain grown in either Nelson's medium, filtered Nelson's medium, casamino acids plus dextrose, or casamino acids alone, the data indicated that the more complex Nelson's medium produced increasing and sustained growth. The millipore filtered Nelson's medium produced significantly less growth. Growth of *N. fowleri* in casamino acids plus dextrose or casamino acids alone was poor.

A comparison of the growth characteristics of two *N. fowleri* strains isolated from different sources (LEE from Richmond, Va. in 1958 and NP66 from Australia in 1966) showed that both strains, when grown in Nelson's medium, have nearly identical growth patterns. The minimum doubling time was 8-10 hours and the maximum concentration (stationary phase) occurred at  $5-6 \times 10^7$  amebae/ml. The only major difference was the appearance of cysts in NP66 and not in LEE cultures. Encystment occurred 170 hours after stationary growth was obtained.

These data indicate a complex nutritional requirement and strengthen the existing evidence that the various *N. fowleri* isolates are indeed the same species.

B10 33

A FURTHER EXAMINATION OF THE INFLUENCES OF PHEROMONES PRODUCED BY FREELY GROWING LABORATORY POPULATIONS ON THE REPRODUCTIVE MATURATION OF PRAIRIE BEEMCHIE. Patricia L. Kippe\*, and C. Richard Ferman. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

Pregnant females were removed from their mates and paired in cages containing bedding from one of the following sources: clean or soiled by populations approaching asymptote. Pregnant females maintained on population bedding received soiled bedding from either the same or a different population each week. Young born to these females were placed as bisexual pairs in different but identical cages at 21-25 days of age and the weekly bedding exchange treatment continued. Records were obtained on births and reproductive condition until all animals were 100 days of age.

Significantly more females reared on bedding soiled by different populations reproduced by 100 days of age than those reared on bedding soiled by the same populations ( $P < .1$ ) or on clean bedding ( $P < .025$ ) whereas there was no difference between the latter two groups. All groups had significantly greater reproduction than the populations from which the bedding came. These findings will be discussed.

B10 34

REPRODUCTIVE CHARACTERISTICS AND CORTICOID LEVELS OF FEMALE WHITE-FOOTED MICE FED *AD LIBITUM* AND RESTRICTED DIETS CONTAINING A PCB. R. L. Kirkpatrick and O. T. Sanders\*. Dept. of Fisheries & Wildlife Sci., VPI&SU, Blacksburg, Va. 24061.

Sixty adult female white-footed mice were used in a 2x3 factorial experiment to study the effects of PCB (Aroclor 1254 at 0, 25 and 100 ppm) ingestion and two nutritional levels (*ad libitum* and 70% *ad libitum*) on reproductive and associated characteristics. The animals were on the two nutritional levels for 5 weeks whereas the PCB was fed during the last 3 weeks only. Restricted feeding caused a significant ( $P < 0.01$ ) body weight loss, and significant ( $P < 0.01$ ) reductions in ovarian and uterine weights but had no significant effects on liver weights, adrenal weights or plasma corticoids. Mean values for the *ad libitum* and restricted animals, respectively, were as follows: body weight change, 1.2 vs -0.6 g; ovarian weight, 15.0 vs 6.2 mg; uterine weight, 38.5 vs 19.6 mg. Restricted feeding also reduced the percent of females exhibiting estrous vaginal smears during the last week of the experiment (59 vs 18%). PCB ingestion significantly increased liver weights ( $P < 0.01$ ) and reduced barbiturate induced sleeping times ( $P < 0.01$ ) and corticoid levels ( $P < 0.05$ ) but had no significant effects on reproductive or other organs studied. Mean values for the 0, 25 and 100 ppm levels of PCB ingestion were as follows: liver weights, 0.91, 1.12 and 1.65 g; sleeping times, 90, 43 and 19 min.; plasma corticoid levels, 40.8, 21.0 and 28.5  $\mu\text{g}/100 \text{ ml}$ . (Supported by FWS Grant No. R01-ES00093)

B10 35

OCULAR INFLUENCE ON ORIENTATION IN THE LARGE MILKWEED BUG, *ONCOPELTUS FASCIATUS*. R. L. Lammann\*, M. A. Kress\*, and N. J. Fashing. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

In addition to the compound eyes, many insects also possess simple eyes (ocelli). The function of the ocelli is poorly understood, but the primary functions are ascribed to photokinesis and phototaxis. The relatively few species of insects which have been investigated all possess three ocelli. We studied ocular influence on phototaxis and photokinesis in *Oncopeplus fasciatus*, an insect possessing only two ocelli. To determine ocular influence, the response of normal (untreated) insects was compared with that of the same insects with one or more ocelli "blinded" with nontoxic black paint. The following results were obtained: PHOTOKINESIS - Individuals with ocelli occluded walked more slowly than with normal ocelli ( $p < .005$ ;  $n = 18$ ). A control demonstrated no significant difference in walking speed ( $p = .58$ ;  $n = 45$ ). PHOTOTAXIS - Individuals with one ocellus occluded demonstrated a significant change in directional orientation toward the side of the occluded ocellus. This was found both in bright light (12,912 lux) ( $p < .005$ ;  $n = 20$ ) and in dim light (43 lux) ( $p < .005$ ;  $n = 12$ ). A control indicated no significant change in directional orientation ( $p = .50$ ;  $n = 21$ ).

In conclusion, the ocelli influence both phototactic and photokinetic orientation in the large milkweed bug.

B10 36

THE APPLICATION OF MANNED UNDERSEA SCIENCE AND TECHNOLOGY TO CHESAPEAKE BAY RESEARCH PROBLEMS. M. P. Lynch, Virginia Institute of Marine Science, Gloucester Point, Va. 23062

Manned undersea science and technology which encompasses use of manned underwater platforms (habitats and submersibles) and/or divers has been extensively applied to research problems of the tropical Atlantic (habitats HYDROLAB, PRINUL, TEKITE) and to northwest fisheries problems (submersibles ALVIN, NEKTON GAMMA). Although divers have been used on some research projects in estuarine and nearshore projects in the mid-Atlantic, no concerted effort to apply manned undersea technology has been encouraged by federal funding initiatives until recently.

The area and volume of Chesapeake Bay and tributaries are approximately 11,220 Km<sup>2</sup> and 74 Km<sup>3</sup> respectively. Because of its shallow nature (79% of the volume and 81% of the area is 30 ft. or less in depth) manned platforms are not suited for this area. Undersea instrument chambers (USIC's) and divers are considered to have strong potential for use in the area.

Limiting factors are poor visibility, low winter temperatures (2.5<sup>o</sup>-4<sup>o</sup>C) and stinging nettles (*Chrysura quinque-cirra*) during summer months. Despite these difficulties a number of techniques developed and tested in habitat operations are believed to have excellent potential for providing insight into Chesapeake Bay problems. Supported by: Manned Undersea Science and Technology (MUS&T) program, U.S. Dept. of Commerce, NOAA.

Bio 37

CHANGES IN *DROSOPHILA* CULTURES RAISED IN A MAGNETIC FIELD. James H. Martin, J. Sargeant Reynolds Community College, Richmond, Virginia 23230.

Using instant media and standard plastic culture vials, wild type *Drosophila* were raised in the pole gaps of permanent magnets. Magnets were obtained from government surplus and wild type flies were obtained from class stock cultures.

Only F<sub>1</sub>'s were observed and observation was made on differences in gross morphology, sex ratios, and maturation time.

As with similar experiments performed by other investigators using comparable magnetic field strengths and gradients, there was no observable difference between control and experimental groups.

A single anomaly which has not been repeated occurred in one experimental vial. The sex ratio was approximately 2 females to 1 male in a total of 821 flies.

Bio 39

EFFECTS OF DIETARY EXPOSURE TO PCB ON TESTICULAR CHARACTERISTICS, ORGAN WEIGHTS, AND PLASMA CORTICOIDS OF MALE WHITE-FOOTED MICE. M. H. Merson\* and R. L. Kirkpatrick, Dept. of Fisheries and Wildl. Sci., V.P.I. 68 U., Blacksburg, Va. 24061

Male white-footed mice (*Peromyscus leucopus*) received 0, 100, or 200 ppm Aroclor 1254 in the diet for four weeks. The animals were caged singly and fed *ad libitum*. Blood was collected upon sacrifice and organs (except testes) were preserved in 10% formalin until weighed. There were no significant effects upon paired adrenal and paired testes weights, body weight change or plasma corticoid levels ( $P < 0.05$ ) due to PCB treatment. Liver weights were significantly increased due to PCB treatment ( $P < 0.01$ ). Spleen weights ( $\bar{X} \pm S.E.$ ) for the 0, 100, and 200 ppm groups were 30.4 $\pm$ 2.7<sup>a</sup>, 37.8 $\pm$ 2.6<sup>a,b</sup>, and 41.9 $\pm$ 4.5<sup>b</sup> mg, respectively. Seminal vesicle weights for the 0, 100, and 200 ppm groups ( $\bar{X} \pm S.E.$ ) were 159.0 $\pm$ 20.5<sup>a</sup>, 111.8 $\pm$ 13.0<sup>a,b</sup>, and 95.1 $\pm$ 16.0<sup>b</sup> mg, respectively. Values with different superscripts were significantly different ( $P < 0.05$ ). Spermatozoa/mg testis and total spermatozoa/testis tended to decrease with PCB treatment ( $P < .18$ ). (Supported by PHS Grant No. R01-ES00863).

Bio 41

ENVIRONMENTAL ASSESSMENT: A COMPARISON OF APPROACHES AND METHODS. Gary F. Martel and Robert T. Lackey, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Federal law requires that all major federally-supported projects be studied in relation to their impact on the environment. Development of a rapid means of assessing environmental impact would be of great value, however attempts have failed to prove themselves satisfactory. Some of the reasons for previous failure have lain in: (1) use of value judgments in making determinations; (2) lack of final impact value on which to base comparisons; and (3) lack of weighting factors to separate important from less important impacts. One possible improvement to the present strategies is through the use of objective ranking as used in decision-making and industry.

Achieved in a three-step process, the procedure would first use subjective input to rank environmental subgroups as to their importance to environmental quality. Different project alternatives would then be evaluated in relation to the environmental subgroups, thus setting up a second matrix. The third step is to combine the two matrices by multiplying the average subjective input from step one by the block values for project alternatives, which yields a multidimensional matrix capable of decreasing subjectivity in assessment, and establishing a firm base for further evaluation.

Bio 38

CUTANEOUS WATER LOSS DURING THE DEVELOPMENT OF THERMOREGULATION IN JAPANESE QUAIL. F.M.A. McNabb\* and R.A. McNabb. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The water permeability of Japanese quail skin was measured as water loss to a desiccant-filled glass capsule closely applied to the skin surface. By 13 days of age, skin permeability approximates that of adults, a 43% decrease from the permeability level of hatching skin. Measurements of histological sections indicate that the thickness of the cornified layer of quail skin increases by 84% in ventral skin and 42% in dorsal skin during this time period. Preliminary studies of evaporative water loss in an open flow system indicate that cutaneous water losses account for about 60% of the total evaporative water loss in quail hatchlings. Thus, cutaneous water loss appears to be a significant avenue of heat loss in hatching quail, but is markedly reduced by the time they become homeothermic at about two weeks of age.

Supported by NSF Grant GB37966.

Bio 40

ANTLER SHEDDING TIMES FOR WHITE-TAILED DEER IN DIFFERENT REGIONS OF VIRGINIA. R. E. Mirarchi,\* M. D. Russell,\* P. F. Scanlon, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

White-tailed deer (*Odocoileus virginianus*) from two confined herds at the Radford Army Ammunition Plant lands at Dublin (D) and Radford (R), in southwest Virginia were observed to determine the timing of antler casting during 1974-75. Similar observations were made on the Naval Weapons Supply Station lands at Cheatham Annex (CA) and Yorktown (Y) in southeast Virginia during the same time period. The proportion of deer seen with antlers cast was determined at weekly intervals for (R) and (D) and on two occasions at (CA) and (Y). Earliest reported antler loss was 6 December in southwest Virginia and 14 December in southeast Virginia. Antlers were lost by approximately 90% of the deer in all study areas in southwest and southeast Virginia by 25 January. Latest incidence of a deer bearing antlers was 31 January (R). Results indicate that antler shedding is underway while the antlered hunting season is in progress in the eastern regions of the state. While results indicate some differences in the timing of antler shedding from available literature reports, there appears to be little difference between study areas in southeast and southwest Virginia. (Supported by McIntire-Stennis Project No. 636201).

Bio 42



RELATIONSHIPS BETWEEN PLASMA ANDROGEN LEVELS AND REPRODUCTIVE CHARACTERISTICS OF WHITE-TAILED DEER. R. E. Mirarchi\*, P. F. Scanlon, R. L. Kirkpatrick and C. B. Schreck. Dept. Fisheries and Wildlife Sciences, Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061.

The left testis, epididymis and a blood sample were collected from each of 55 adult (>12 months) male white-tailed deer over approximately one year in southwest Virginia. Testes weights (g) were heaviest in November (46.76 ± 8.16 S.E.) and lightest in March (7.83 ± 1.00 S.E.). Epididymis weights (g) were heaviest in November (7.40 ± 1.11 S.E.) and lightest in June (2.55 ± 0.17 S.E.). Total testicular spermatozoan numbers (TSN) ( $10^9$ ) were highest in November (4,406 ± 0.572 S.E.) and lowest in May (0.020 ± 0.012 S.E.). Total epididymal spermatozoan numbers (ESN) ( $10^9$ ) were highest in November (6,602 ± 1.600 S.E.) and lowest in June (0.003 ± 0.003 S.E.). Plasma androgens (ng/ml) were greatest in November (31.23 ± 11.03 S.E.) and smallest in June (1.14 ± 0.36 S.E.). Organ weights, spermatozoan numbers, and androgen levels indicated maximum male reproductive capability in November at the peak of the breeding season. Androgen concentrations were highly ( $P < 0.001$ ) correlated with testis weight ( $r = 0.45$ ), epididymis weight ( $r = 0.49$ ), TSN ( $r = 0.51$ ), and ESN ( $r = 0.51$ ). Low  $r$  values are indicative of the inverse exponential relationship occurring between androgen and gonadal variables. [Supported by McIntire-Stennis Project No. 636201].

Bio 43

ZINC STIMULATION OF PYGIDIAL BUDDING IN *AELOSOMA HEADLEYI* BEDDARD (ANNELIDA). J. Preston Newman, Jr. and Arthur L. Buikema, Jr. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Worms which had reproduced were immediately exposed to 0.01, 0.05, 0.1, 0.5, 1.0, and 5.0 ppm Zn and were timed for production of the next two buds. The 0.05 and 5.0 ppm Zn significantly decreased the time until first bud formation. A regression of time between buds and Zn concentration was significantly negative. The time to second bud formation showed no significant treatment effect, but the regression slope was positive. Low levels of Zn may still stimulate the second bud.

Another experiment was conducted with 0.01, 0.05, 0.1, 0.5, 1.0, 5.0, 12.0, 24.0, and 36.0 ppm Zn. If Zn was added immediately after budding the results for the time to next bud formation were not significant. The regression of sublethal concentrations of Zn to time of second bud formation was significantly positive.

If Zn was added 36 hrs. after prior budding, the regression was significantly negative. In 24.0 and 36.0 ppm the worms budded quickly and then both the adult and bud died. The time to second bud formation was significantly positive.

Bio 44

POPULATION CHARACTERISTICS AND DENSITIES OF THE PINE VOLE IN A MAINTAINED AND AN ABANDONED ORCHARD. R. E. Moffainger\*, R. L. Kirkpatrick, and J. E. Ester\* Dept. of Fisheries and Wildlife Sci., Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061.

Pine voles (*Microtus pinetorum*) were snap-trapped bi-monthly from Sept. 1974 to March 1975 in a maintained and an abandoned apple orchard near Roanoke, Va. Approximately fifty voles were captured in each orchard, each trapping period. Eye lens weights were used to age voles, and from these data a time-specific life table was developed for each orchard. Mean monthly mortality rate for the maintained orchard was 18% and for the abandoned was 23%. Immature to adult ratios in the two orchards indicated higher reproduction in the maintained orchard in all months. September ratios were 27:73 and 18:82, November ratios were 29:71 and 24:76, January ratios were 25:75 and 13:88, and March ratios were 2:91 and 0:100, in the maintained and abandoned orchard respectively. The relative density index used (voles caught per 100 trap hours) indicated similar densities in both orchards through January. This may have been a result of greater catchability in the abandoned orchard rather than greater densities. The greater natality and lesser mortality indicates higher densities in the maintained orchard. (Supported in part by the U.S. Fish and Wildlife Service).

Bio 45

SMALL MAMMALS OF THE PADDY KNOB-LITTLE BACK CREEK AREA OF BATH COUNTY VIRGINIA. John F. Pagels and Cathy M. Tate.\* Dept. of Biology, Virginia Commonwealth University, Richmond, Va. 23284

Sixteen species of mammals, exclusive of forms considered game or furbearing, were captured in the period 1972-1974. Trapping efforts were concentrated near a wildlife clearing just below Paddy Knob (elevation ca. 4000 ft.) and in the area of headwaters of Little Back Creek (elevation 3600 to 3000 ft.). More than two thirds of the forms taken were shrews and bats. Dependent on habitat, species encountered most often were shorttail shrews, *Blarina brevicauda*, eastern meadow vole, *Microtus pennsylvanicus*, and deer mice, *Peromyscus maniculatus*. Based on captures the least common forms were the long-tailed shrew (rock shrew), *Sorex dispar*, and the water shrew, *Sorex palustris*.

Bio 46

CHANGES IN AMOUNT AND COMPOSITION OF GELATIN FROM DEVELOPMENTAL STAGES OF THE SCYPHOZOAN JELLYFISH, *PHYSALIA QUINQUEFIDRATA*. J. L. Quisenberry\* and R. B. Black. Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061. Gloucester Point, Va. 23062 and Dept. of Biology, College of William and Mary, Williamsburg, Va., 23185

When extracted in the form of gelatin after autoclaving, collagen from whole scyphistomae, ephyrae, and adults was found to have an unusual amino acid composition with high glutamic acid and low glycine content. The percent molality of glutamic ranged from 31% in the poly to 15% in the adult, while that of glycine ranged from 7% to 11% respectively. Protein obtained without autoclaving from isolated mesoglea of medusae contained 26% glycine and 12% glutamic, thereby resembling typical invertebrate collagen. The high glutamic acid of gelatin from whole organisms must therefore be derived from a component extracted from the cells, rather than from mesoglea.

Protein determinations indicated that gelatin constitutes a minimum of 44% of poly total protein and a maximum of 80% of adult protein.

Bio 47

INTENSITY AND PERSISTENCE OF TWO FLUORESCENT MARKERS IN WOODCHUCKS, MICE, AND QUAIL. S. W. Ruckel\*, J. D. Maine\*, and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Demethylchlorotetracycline (DMCT) and Rhodamine B were tested as fluorescent markers in woodchucks (*Marmota monax*), white mice (*Mus musculus*), and Japanese quail (*Coturnix japonica*). A single 10 mg dose of DMCT given mice by gavage resulted in no fluorescence of mandibles or incisors at 15 or 30 days. One of five mice showed incisor fluorescence at 45 days and two of five mice at 60 days. Rhodamine B fluorescence was obvious on all mice pelts for the duration of the study (60 days). DMCT fluorescence could not be detected in bones of quail at any time and external Rhodamine B fluorescence persisted only 5 days. Rhodamine B persisted in feces of both mice and quail up to 4 days. Six woodchucks were given a single 10 mg/kg oral dose of DMCT and six others were given a 50 mg/kg dose of DMCT. Two woodchucks from each dose level were sacrificed at 30, 60, and 90 days and incisors, molars, and scraped mandibles examined for fluorescence. Mandibles appeared to be the most promising indicator of fluorescence, with incisors almost as reliable. Intensity of fluorescence was significantly ( $P < .05$ ) greater at 90 days than at 30 days. There was no apparent difference in incidence or intensity of fluorescence between dose levels. Rhodamine B was effective as an external marker of captive woodchucks for the duration of the study. [Supported by McIntire-Stennis Project No. 636201].

Bio 48

SEASONAL AND AGE DIFFERENCES IN MALE REPRODUCTIVE ORGAN WEIGHTS OF WHITE-TAILED DEER. M. D. Russell\*, J. A. Wesson III\*, R. L. Kirkpatrick, and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061.

Reproductive organs were recovered from 110 male white-tailed deer (*Odocoileus virginianus*) collected from six southeastern states during four seasons of the year. The following data were recorded: pituitary weights, pineal weights, paired testes weights, paired epididymal weights, and seminal vesicle weights. Deer were divided into three classes: (1) 0.5-1.25 yr, (2) 1.5-2.25 yr, and (3) 2.5 plus years. Data were analyzed by analysis of variance. Significant ( $P < 0.01$ ) effects of age were observed on the following organs: pituitary, testes, epididymides, and seminal vesicles. Weights of all organs were increased with age. Significant ( $P < 0.01$ ) effects of season were observed on pituitary weight, testes weight, epididymides weight, and weight of seminal vesicles. Weights of all organs were heaviest in fall. Significant interactions between season and age were observed on testes, epididymides, and seminal vesicles. Pineal weights were unaffected by season or age. [Supported by McIntire-Stennis Project No. 636201.]

Bio 49

THE RESPONSE OF AFLATOXIN B<sub>1</sub> ON FEED AND WATER CONSUMPTION IN THE AMERICAN COCKROACH. P. C. Sherertz\*, R. R. Mills\* and G. C. Llewellyn, Dept. of Biology, Va. Commonwealth Univ., Richmond, Virginia 23284

Recent reports in the literature indicate the toxic and carcinogenic effects of aflatoxin B<sub>1</sub> on various animals but little work has been completed on the effects in insects. Thus, adult, male *Periplaneta americana*, selected at random from our colony, were tested in this study. Animals were housed individually in special cages. Three groups, each containing six animals, were fed a diet composed of finely ground dog chow containing varying levels of pure aflatoxin B<sub>1</sub>. Animals in Group I controls received 0 ppm aflatoxin B<sub>1</sub> in their diet. Group II (low concentration) received diets contaminated with 50 ppm and Group III (high concentration) received 200 ppm. Food and water consumption and animal weights were recorded weekly and mean values were determined. All control animals ate and drank at regular intervals. Eating and drinking intervals were cyclic in nature. At seven weeks the accumulative food consumption ranked by groups was as follows: low > control > high. Accumulative food results at 14 weeks were as follows: control > low > high. This ranking may be attributed, partially, to the ability of the animal to taste the toxin in the diets. Accumulative water consumption at 7 weeks, ranked by groups was low > control > high. Similar results were also seen after 14 weeks.

Bio 51

ASPECTS OF REPRODUCTIVE BEHAVIOR OF CAPTIVE WHITE-TAILED DEER. R. W. Vogelsang\*, R. J. Warren\*, R. L. Kirkpatrick, and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, VPI&SU, Blacksburg, Va. 24061.

Observations on reproductive behavior of captive yearling white-tailed deer (20 females and 3 males) were made from 8, November 1974 to 2, January 1975. Females were introduced singly into a 27 m<sup>2</sup> pen with one of the males for a period of 5 to 10 minutes daily. Typical behavior of males when a female entered the pen was to lick and smell the tarsal glands and urogenital area, and frequently exhibit a lip curl and the stereotyped male behavior known as Flehmen. Females not in estrus would not allow the male to mount and would run if he persisted. During estrus, the female was more docile and would permit the male to mount. The mean ( $\pm$ S.E.) number of mounting attempts by a male was 4.2 $\pm$ 0.8. The time from introduction of an estrous female into a male's pen until breeding occurred, averaged 4.3 $\pm$ 0.8 minutes. Copulation terminated with a large thrust by the male and the female immediately assumed a urinating position which averaged 46.2 $\pm$ 5.1 seconds. The male frequently urinated and licked his penis with the mean being 2.6 $\pm$ 0.7 and 3.4 $\pm$ 0.7 minutes after copulation, respectively. If the female was left with the male, the time from the first mating to the next mounting attempt averaged 9.5 $\pm$ 1.4 minutes. The mean number of days between estrous periods was 25.6 $\pm$ 1.9 days based on observations on four of these does which recycled and three older does.

Bio 53

THE EFFECTS OF SUBLETHAL CONCENTRATIONS OF ZINC AND NICKEL ON THE PHOTONEGATIVE RESPONSE OF *DUGESIA TIGRINA*. C. L. See\*, A. L. Buikema, Jr., and J. Cairns, Jr., Department of Biology, VPI&SU, Blacksburg, Virginia 24061

Planaria were acclimated to 50 ppm hardness water, darkness, and 22  $\pm$  1°C. The effect of acute and chronic exposure to 4 concentrations of zinc (2, 1.5, 1, 0.5 ppm) and 3 concentrations of nickel (1.5, 1, 0.5 ppm) on locomotion was studied, specifically the time to move 5 cm from the center of a circle of light was measured. Response time was measured at 24, 48, and 96 hours for the following conditions: original control water; changed control water; changing control water to water + metal; original water + metal; changed water + metal; and changing water + metal to control water.

Statistical analyses of the data showed that the response times among groups varied, response times among various metal concentrations differed, and a significant interaction between groups and metal concentrations occurred.

There is no simple relationship between concentration of zinc and speed of locomotion. A comparison of zinc and control water showed a decrease in crawling speed. After 96 hours as zinc concentration increased up to 1.5 ppm, the depressed effect was less. At 2 ppm zinc crawling speed was increased.

The effect of nickel was noticeable after 48 hours of exposure. Comparing 96 hour data crawling speed was depressed as concentrations of nickel increased.

Bio 50

ZINC EFFECTS ON CELL DIVISION AND CALCIFICATION IN THE COCCOLITHOPHORID, *CRICOSPHERA CARTERAE*. E. F. Stillwell\*, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Coccolithophorid algae deposit on the cell surface coccoliths composed of calcium carbonate in an organic matrix formed on scales within Golgi vesicles. Zn<sup>2+</sup> was found to produce effects on cell division and coccolith formation in *Cricosphaera c.* decalcified with CO<sub>2</sub>. Compared with controls (0.18  $\mu$ M Zn) the rate of division decreased almost linearly with added Zn<sup>2+</sup> concentrations. (0.7-7  $\mu$ M) until division was blocked completely at 10.5  $\mu$ M Zn<sup>2+</sup>. Inhibition of cell division was reversible after 10 days in Zn. Also compared with controls recalcification of cells decalcified with CO<sub>2</sub> decreased linearly with added Zn<sup>2+</sup> with complete inhibition in 10.5  $\mu$ M Zn<sup>2+</sup>. After 3 days, cells which had partially recalcified (Zn<sup>2+</sup> conc. 1.4  $\mu$ M-7  $\mu$ M) showed detachment and losses of external coccoliths in substantial numbers by day 10. Controls showed no coccolith losses. Reversal of this decalcification in all cells occurred following a change to normal sea water.

Bio 52

EFFECTS OF MIREX AND A PCB ON PENTOBARBITAL-INDUCED SLEEPING TIMES AND ORGAN WEIGHTS OF MALE COTTONTAIL RABBITS. R. J. Warren\*, R. L. Kirkpatrick, and R. W. Vogelsang\*. Dept. of Fisheries and Wildl. Sci., VPI&SU, Blacksburg, Va. 24061.

Fifteen male cottontail rabbits (*Sylvilagus floridanus*) were divided into three groups and were used to compare the effects of 25 ppm dietary Mirex and Aroclor 1254. Following treatment for 14 days the animals were injected ip with sodium pentobarbital at a dosage of 45 mg/kg. Induced sleeping time was measured as an indication of hepatic microsomal enzyme activity. After 20 days of treatment the animals were sacrificed, and the liver, adrenals, testes, prostate, and seminal vesicles were removed and weighed. Daily food consumption and serum corticosterone levels were also determined; they were unaffected by treatment. Liver weights were significantly greater ( $P < 0.05$ ) in the Mirex-treated rabbits and tended to be greater ( $P < 0.10$ ) in the PCB-treated animals. Mean ( $\pm$ S.E.) liver weight for controls was 25.9 $\pm$ 2.1 gm compared to 35.4 $\pm$ 2.2 gm and 31.1 $\pm$ 1.4 gm for the Mirex- and PCB-treated animals, respectively. Sleeping times of the treated animals were generally shorter than for controls ( $P < 0.10$ ). Sleeping times were 18 $\pm$ 17, 14 $\pm$ 6, and 13 $\pm$ 17 minutes for the control, Mirex-, and PCB-treated animals, respectively. The results indicate that 25 ppm Mirex and Aroclor 1254 possess similar hepatic microsomal enzyme inducing capabilities when fed to cottontails. (Supported by FHS Grant No. R01-ES00863).

Bio 54

CHANGES IN PACKED CELL VOLUME OF WHITE-TAILED DEER FOLLOWING ADMINISTRATION OF IMMOBILIZING DRUGS. J. A. Wesson III\* and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ. Blacksburg, Va. 24061.

Ninety-five captive white-tailed deer (*Odocoileus virginianus*) were bled repetitively 4 times in association with a restraint facilitating drug treatment or with physical restraint. Drug treatments were Succinylcholine chloride (SCC), RO-5-3448 (RO, Hoffmann-La Roche) and a combination of Phencyclidine Hydrochloride and Promazine Hydrochloride (PH). Packed Cell Volumes (PCV) were determined at each bleeding. PCV declined significantly ( $P < 0.05$ ) following PH treatment. A significant ( $P < 0.05$ ) decline in PCV was observed during immobilization by SCC but PCV rose again with recovery. Significant ( $P < 0.05$ ) changes in PCV were not associated with RO treatment except a decline in females at 150 minutes after treatment. Significant changes in PCV were not observed in 35 manually restrained deer.

[Supported by McIntire-Stennis Grant No. 636201.]

Bio 55

RESPONSE OF WHITE-TAILED DEER TO THREE IMMOBILIZING DRUGS. J. A. Wesson III\* and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

Each of three restraint facilitating drugs was administered to 20 captive white-tailed deer (*Odocoileus virginianus*), and individual responses were observed and recorded. Succinylcholine chloride solution, a neuromuscular depolarizing agent, was injected intramuscularly at doses ranging from 3.8 to 6.0 mg per deer (0.078 mg/kg). The mean time to immobilization was 9.35 min ( $\pm 0.95$  SE) (range = 4 to 23 min). The time from immobilization to recovery was 38.05  $\pm$  4.39 min (range = 19 to 86 min). Two deaths resulted. Phencyclidine hydrochloride (Sernylan), a dissociative anesthetic, and promazine hydrochloride (Sparine, Wyeth Labs), a tranquilizer, were combined and given intramuscularly. A dose of 200 mg Sernylan and 150 mg Sparine was effective in all adult deer studied. Immobilization occurred in 4.80  $\pm$  0.33 min (range = 3 to 8 min). Deer began recovering in 45 to 180 min (108.95  $\pm$  8.76 min) and were standing in 68 to 210 min (139.65  $\pm$  10.86 min). Results were excellent. RO-5-3448 (Hoffmann-La Roche, Inc.) is a tranquilizer which was given orally at doses of 600 to 800 mg/deer ( $> 10$  mg/kg). Effects were apparent in 10 to 60 min (mean = 45 min) and lasted 12 to 72 hr (maximum effect at 2-12 hr). Results were good although deer were only tranquilized and not immobilized. [Supported by McIntire-Stennis Grant No. 636201.]

Bio 56

BEHAVIOR OF YEARLING WHITE-TAILED DEER ORPHANED AS FAWNS.

D. L. Woodson\*, B. S. McGinnis\*, and R. L. Downing\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

A study involving 45 ear-tagged yearling white-tailed deer (*Odocoileus virginianus*), 21 of which had been orphaned as 4 to 6 month-old fawns, was conducted from March through December 1974 at the Radford Army Ammunition Plant, Dublin, Va. The objectives were to determine the effects of orphaning on (1) survival, (2) changes in home range, (3) changes in social behavior, and (4) body and antler growth. Orphaning did not appear to affect yearling survival, their body and antler growth, or the percentage of time they were seen alone. Orphans were found to associate with smaller groups, to associate less often with an adult doe, and to group with fewer does and fawns than did non-orphans. Orphaned males were found to move further than 1.6 km from their center of activity significantly ( $\alpha = 0.1$ ) more often than other yearlings, but this difference was mainly due to the mobility of 2 pairs of orphaned male twins. Only 7 yearlings, all males, made a significant change in home range. The only unique characteristic of these bucks seems to be that 5 of the 7 had a male sibling. Only 1 deer dispersed prior to late May, so the disruptive influence of the fawning season and the profuse growth of succulent vegetation during this period may have induced the other 6 yearlings to disperse.

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SCANSORIALITY IN THE COTTON RAT, *SIGMODON HISPIDUS*. Dale E. Wright\* and John P. Pagala. Dept. of Biology, Virginia Commonwealth University, Richmond, Va. 23284

Cotton rats, *Sigmodon hispidus*, and meadow voles, *Microtus pennsylvanicus*, especially, are rodents primarily confined to runways in old-field situations. Our data indicate that these forms take advantage of food items available above ground level, at least during periods when low-lying vegetation is depleted. In laboratory studies, the cotton rats climbed to heights of over three feet. *Sigmodon* also climbed to this height when the climbing apparatus was elevated from the floor necessitating an initial jump. In the field, several cotton rats were taken 7 to 10 inches off the ground using snap traps attached to honeysuckle, *Lonicera japonica*. The white-footed mouse, *Peromyscus leucopus*, the harvest mouse, *Reithrodontomys humilis*, the eastern meadow vole, *Microtus pennsylvanicus*, and the house mouse, *Mus musculus*, were also taken in traps placed above ground level in honeysuckle.

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## Abstracts of Papers Section of Botany

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

EFFECT OF GERMINATION ON *IN VITRO* PROTEIN SYNTHESIS BY RIBOSOMAL AND SUPERNATANT FRACTIONS FROM SUGAR PINE SEEDS. R. E. Adams<sup>\*</sup>, L. B. Barnett, and J. A. Ramsey<sup>\*</sup>. Depts. of Forestry and Forest Products, and Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Protein synthesis by ribosomes and supernatant fractions from germinating sugar pine (*Pinus Lambertiana* Dougl.) seeds was studied in an *in vitro* system. Ribosomes and pH 5 fractions prepared from embryos during the first 3 days of germination supported protein synthesis at levels similar to fractions prepared from stratified embryos. However, ribosomes from female gametophytes increased fourfold in their capacity to support protein synthesis during the same period. (Supported by McIntire-Stennis Grant 636223 and Hatch Grant 61611)

ORCHIDS OF THE MASSAMUTTEN MOUNTAIN. Lena C. Artz, Sarah P. Faulconer and Harlin F. Krouse<sup>\*</sup> P. O. Box 2, Strasburg, Virginia, 22657.

The United States has 70 some species of native orchids. Virginia has 50 some species and 20 are found in the Massanutten Mountain.

These orchids are frequently found in bogs within the mountain, but, unfortunately, these choice habitats are in danger of becoming obliterated. Developments with second homes, ski slopes, etc., unwise forestry practices, together with the fact that people do not seem to realize that bogs are very important places for water storage and for cool habitats for plants and animals, are all posing threats to the continued existence of many of our native Massanutten orchid species.

BRYOPHYTES OF A PIEDMONT FLOODPLAIN. D.A. Breffl. Dept. Natural Sciences, Longwood College, Farmville, Va. 23901

Bryophytes were collected on the densely wooded floodplain of the Bush River near Farmville, Va. Dominant trees of this forest include river birch (*Betula nigra*), American elm (*Ulmus americana*), pin oak (*Quercus palustris*) and bitternut hickory (*Carya cordiformis*).

Collections of bryophytes were made along four parallel transects across the floodplain during the summer months and spot checked throughout an entire year. Four microhabitats were investigated. These included (1) soils, (2) logs, (3) trees, and (4) soil at the margins of the river and sloughs. Mosses found on the soil included *Minium cuspidatum*, *Brachythecium oxycladon*, and *Leptodictyum riparium*. A pleurocarpus moss, *Leskea polycarpa*, blanketed most of the moist rotten logs although *Entodon cladorrhizans* was locally common. Trees exhibited the greatest diversity and zonation of bryophytes. The most common of these were *Anomodon attenuatus*, *Leskea gracilescens*, *Frullania inflata*, *Clasmatodon parvulus*, *Porrella platyphylla*, *Cryphaea glomerata*, and *Orthotrichum ohioense*. Thallose liverworts occur most commonly along the margins of the river and sloughs in spring and fall months. *Anthoceros laevis* ssp. *carolinianus*, *Riccia sullivantii*, *Notoflytes orbicularis*, and *Fossombronella foveolata* are the normal but temporary colonizers.

A SEASONAL STUDY OF THE PHYTOPLANKTON OF BACK BAY, VIRGINIA - INTERIM REPORT. E. R. Comegys and H. G. Marshall, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Phytoplankton and concomitant environmental parameters have been sampled monthly in Back Bay over a period of six months (July-Dec 1974). A diversified plankton flora, consisting of seven divisions, forty one genera, and ninety species has been recorded. Major divisions include Cyanophyta, Chlorophyta (mostly desmids), and Chrysophyta (mostly diatoms). Less represented divisions are Euglenophyta, Pyrrophyta, and Charophyta. Comparisons with other regional estuarine and limnetic studies favor a characterization of the Back Bay flora as a shallow, predominantly fresh water influenced composition, despite low but measurable salinity. The desmid and diatom components are comparable to those of Coastal Plain lakes and ponds. However, a marked persistent dominance of both filamentous and non-filamentous Cyanophyta serves to distinguish Back Bay from other Coastal Plain habitats which have been studied. Quantitative data indicate 1) a seasonal decrease in total cells per liter between August and September, 2) an October pulse varying in intensity and contributing component species at two sampling stations, 3) a November-December rise in cell abundance at both sampling stations.

NOTES ON THE CHEMOTAXONOMY OF STIRPS ADIPOSA OF THE GENUS PHOLIOTA. G. B. Dawson\*, O. K. Miller, Jr. and A. R. Linkins Dept. of Biology, Virginia Polytechnic Institute & State Univ., Blacksburg, Va.

In a recent study of the stirps *Adiposa* in the genus *Pholiota*, the species *P. abietus*, *P. connata*, *P. squarrosa-adiposa* and *P. subvelutipes* have been reduced to synonymy with *P. squarrosa*. Chemotaxonomic studies to further elucidate this species complex by the use of disc electrophoresis have been initiated. Protein from vegetative growth of the species in liquid culture has been extracted and fractionated. Electrophoresed protein is then stained with Coomassie Blue R for detection of general protein. The banding patterns are used to demonstrate relationships within the stirps *Adiposa*. Initial results show difference in protein components of the three closely related species.

THE SENECEIONAE (ASTERACEAE) IN VIRGINIA. Jeff J. Doyle, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

The tribe Senecioneae in Virginia, comprised of *Senecio* (9 species), *Cacalia* (3 species), *Arnica*, *Tussilago*, and *Erechtites* (1 species each) is treated systematically. Keys, descriptions, flowering and ecological data, chromosome numbers, and distribution maps for the state are provided. *Senecio pauperculus* is reported new to the flora. The hybrid nature of *Senecio A. crawfordii* is discussed.

TWO ENIGMATIC ZEPHYRANTHES, *Z. BIFOLIA* AND *Z. CANDIDA*.

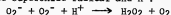
Walter S. Flory and Gerald Smith\* Biology Dept., Wake Forest U., Winston-Salem, N.C. 27109.

Of 27 *Zephyranthes* species studied cytologically, most (74%) have somatic numbers divisible by six, with practically all chromosomes being metacentric with about equal-lengthed arms. Most species have complements made up of similar type chromosomes, except for length, which usually vary from about 4 to 15 microns following colchicine treatment.

Of the 2 species discussed here, one is *Z. candida* Herb., an aneuploid with  $2n=38$ , and has narrow, thickened, leaves with thickened edges, unlike those of any other taxon. Herbert originally suggested the name *Axyropros candida* for this species, which is apparently the most cold-hardy member of the group. The second species considered here is the quite variable *Z. bifolia* (Aublet) Roemer from Santo Domingo. Collections from eight locations and elevations on that island have a range of flower colors from white, through pink, peach, and orange to dark red. All these apparently have 60 somatic chromosomes, but the complement is composed of 5 pairs of exceptionally long, and of 25 pairs of much shorter chromosomes of several size classes. Wright had named this form *Habranthus cardinalis*, Sealy (1937) suggested it was a hybrid. Padre Julio Cicero, a current worker, has suggested the orange tones have been introduced into *Z. bifolia* by hybridization with *Amaryllis puniceum*, of the same island, but the chromosome situation appears to refute this possibility.

THE ANALYSIS OF SUPEROXIDE DISMUTASE IN COTTON LEAF TISSUE. Joyce G. Foster\*, and John L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Superoxide dismutase catalyzes the dismutation reaction between the superoxide radical and  $H^+$ .



The enzyme has been isolated from photosynthetic tissues and in spinach identified as a chloroplastic enzyme. However, its contribution to plant metabolism is not understood.

We prepared homogenates from cotton leaf and stem callus tissue. Leaf homogenates required extensive protection against cellular oxidation of endogenous phenolic materials. Protein was precipitated at pH 7.0 with saturated  $(NH_4)_2SO_4$  and dialyzed against 0.01 M Tris-Cl pH 8.0. Dismutase was assayed by the standard xanthine oxidase method, inhibition of the autooxidation of epinephrine, and inhibition of formazan formation on acrylamide gels.

*Gossypium herbaceum* 1697 and 2485 were compared; we observed dismutase activity within the same order of magnitude for both varieties. Polyacrylamide gel electrophoresis revealed the presence of four major bands of superoxide dismutase activity. For both varieties one band had mobility similar to the well characterized enzyme from *E. coli*; the other three bands were more anionic. Localization and control of these forms of the enzyme are being studied. (Supported by CSRS Grant No. 316-15-93)

THE EFFECT OF GLYPHOSATE ON THE GROWTH OF *LEMNA PERPUSILLA*. T. Gianfagna and C. L. Foy, Dept. of Plant Pathology and Physiology, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061.

The effect of glyphosate [N-(phosphonomethyl)glycine] on the growth of *Lemna perpusilla* was studied by bioassay to determine the biochemical and physiological effects of glyphosate inhibition on plants. One-half maximal growth inhibition occurred by the addition of 0.4mM glyphosate to the nutrient medium. At 0.2mM concentration, glyphosate inhibition was detected within 24 hrs. by measuring changes in dry weight. Other parameters indicative of growth were also evaluated. The mean frond area was decreased by 63%, and the total frond number was reduced after the incubation of plants for 6 days in 0.2mM glyphosate.

The addition of a variety of compounds to the nutrient medium confirmed that certain amino acids, alone and in combinations, could act as reversing agents, effectively reducing the inhibitory effects of glyphosate. Since amino acid metabolism appeared to be altered by glyphosate, total protein and the incorporation of  $^3H$ -leucine into protein were determined at intervals following treatment. Glyphosate decreased total protein and inhibited the protein synthesis. Certain amino acids added along with glyphosate reduced the inhibition.

AN ANALYSIS OF MORPHOLOGICAL VARIATION OF *ASTER ACUMINATUS* NICHK. IN VIRGINIA AND THE SOUTHEAST. L. Michael Hill, Dept. of Biology, Bridgewater Col., Bridgewater, Va. 22812.

Four populations of *Aster acuminatus* were sampled from localities in Virginia and West Virginia. Data were also obtained from over 400 herbarium specimens representative of the geographic range of this taxon. Quantitative and qualitative characters were subjected to a morphological hybrid index, as well as, standard statistical analysis. Results indicated that variation was habitat-correlated and representative of previous genetic contact with *Aster nemoralis* Ait. The latter taxon is an aster of bog and wet places. When the ranges of the two species overlap, hybridization results. *A. nemoralis* is not located in Virginia and West Virginia. (Aided by grants from the Va. Acad. of Sci. and the Soc. of the Sigma Xi).

QUANTITATIVE STEREOLOGY-A NEW METHOD FOR WOOD IDENTIFICATION. Geza Ifju, Jay A. Johnson, and James H. Steele. Dept. Forestry & Forest Products. VPI & SU, Blacksburg, Va. 24061

Traditional wood identification methods are based on a series of subjective decisions regarding the sizes and size distributions, as well as the spatial distribution of the various anatomical elements comprising the secondary xylem tissues. Many if not all the criteria for those decisions may be quantified. In order to quantify wood anatomy and provide an aid for microscopic identification stereological counts were applied to transverse sections of closely related and widely different deciduous wood species. Anatomical elements, such as vessels, fibers, and ray cells were distinguished. In addition, wall and lumen of each element were distinguished. Point counts were used for determining volume fraction of each anatomical element. Intercept counts were used for estimating size and surface area of features as well as for calculating mean free path between and within elements. Aspect ratios of oriented features were also obtained from intercept counts. Feature counts allowed estimation of the moments of size distribution using the deHoof technique. This first effort of applying stereological techniques to quantitative characterization of wood appeared promising. It revealed certain subtle distribution patterns never before recognized using conventional methods. All species studied, including those closely related, could be easily and positively identified on the basis of several statistics calculated from the data.

FUNGI IN TUNDRA SOILS. G.A. Laurson and O.K. Miller, Jr., Department of Biology, V.P.I. & S.U., Blacksburg, Va. 24061.

Thirty-three plots representing five habitats in coastal Arctic tundra were sampled for belowground fungal biomass. The habitats represent three areas of polygonally patterned ground within the 1400m<sup>2</sup> U.S. IBP Tundra Biome site near Barrow, Alaska. Sampling was carried out over three field seasons (1972-74). A modified Jones and Hollison (1969) agar film technique for direct observation and counting of mycelial lengths in an from a non-nutritive water-agar-peat soil solution was used. The three season average was 712.6 mg/g and 1.457 g/m<sup>2</sup> dry wt. Fungal abundance on polygon rims was consistently high and on tops was consistently low for both values. Meadows were less than rims, but generally higher than either wet habitats of trough or basin. Fluctuation in fungal biomass was correlated with soil moisture, soil bulk density, temperature,  $\text{NH}_3$ ,  $\text{NO}_2$ - and  $\text{NO}_3$ - nitrogen, phosphorus and total soil carbon (organic matter). The observed variations resulted from interaction of these factors. Seasonal fluctuations in biomass showed a repeating pattern of vernal highs, mid season lows, a buildup to fruiting of the higher fungi in August, followed by late season declines in biomass. Amplitudes of fluctuation were most pronounced at the soil surface.

THE DISTRIBUTION OF *PIERIS FLORIBUNDA* (MOUNTAIN PETERBUSH) IN VIRGINIA. Stephen Lilly\*. Dept. of Biology, Madison College, Harrisonburg, Va. 22801

*Pieris floribunda* (Pursh) Benth. & Hook. is an ericaceous shrub that is often mistaken for *Kalmia latifolia* L. due to the superficial resemblance of their vegetative structures. It is a reasonable assumption that this phenotypic similarity has resulted in overlooked populations which, in combination with the lack of taxonomic work on the genus *Pieris*, has lead to inadequate reports concerning its distribution. While *Kalmia* is found virtually statewide, *Pieris* occurs only in the mountainous western part of the state; specifically, on the Allegheny and Shenandoah Mountain ranges. Most populations are found at high elevations and in rather moist, open areas. An examination of suitable habitats in the state indicates that the northern-most population is located on Shenandoah Mountains in Shenandoah County while it extends southward along the above mentioned ranges for the entirety of the state. The total absence of native populations of this species in what are apparently suitable habitats on the adjacent Massanutten and Blue Ridge ranges indicates that environmental conditions alone are not the limiting factors governing geographic distribution.

THE *PLEUROSPUS* *SAPIDUS*-*OSTREATUS* COMPLEX: DI-MON MATINGS IN THE GENUS *PLEUROSPUS*. D.L. Manning. Dept. of Biology, V.P.I.&S.U., Blacksburg, Va. 24061.

Dikaryotic-monokaryotic (Di-Mon) matings were made using seven dikaryotic isolates representing six species of *Pleurotus*. The dikaryotic isolates included two from Europe representing *P. eryngii* and *P. cornuopis*, and five from the U.S.A. representing one each of *P. ostreatus*, *P. columbicus*, *P. sinuatus*, and two of *P. sapidus*. These isolates were crossed with four monokaryotic mating type isolates obtained from a fruiting body produced in culture from a European isolate of *P. ostreatus*. All four of the monokaryons were dikaryotized by the two *P. sapidus* isolates, as evidenced by the production of clamp connections in the monokaryons. No dikaryotization occurred with the other isolates. These data suggest that the European *P. ostreatus* and the *P. sapidus* found in the U.S.A. are the same species, while the *P. ostreatus* found in the U.S.A. is not the same species as the European *P. ostreatus*. The other isolates tested also appeared to be distinct from the European *P. ostreatus*.

THE USE OF REMOTE SENSING IN PHYTOPLANKTON STUDIES. Harold G. Marshall. Dept. Biological Sciences, Old Dominion Univ., Norfolk, Va.; David G. Bowker and W. G. Witte, NASA-Langley Research Center, Hampton, Va.

Sea stations were established along transects extending from shore seaward at two sites off the Virginia coast. Phytoplankton composition and concentrations were noted at each station along with surface chlorophylls, temperature, and salinity values. These observations were noted during periods of ERTS overflights. MSS radiance values of each station were then taken from positive transparency images with a densitometer. A comparison of station and radiance data was made to determine positive correlations and the feasibility of ERTS for monitoring phytoplankton and related productivity information in offshore waters. The data indicated that the ERTS MSS is not very suitable for monitoring chlorophyll and related phytoplankton concentrations. Although direct correlations were found in relation to chlorophyll and phytoplankton values, the radiance values were also influenced by other factors such as suspended sediment (or particulates) in coastal waters. Relationships between turbidity, suspended materials, and phytoplankton levels were noted. Species composition and total concentrations of the phytoplankton were discussed in relation to the type and level of chlorophyll.

(Supported by NASA contract NAS5-21816)

SEASONAL FLUCTUATIONS OF NATURAL AND THERMALLY INFLUENCED POPULATIONS OF ALGAE IN THE JAMES RIVER. E. G. Maurakis\*, W. S. Woolcott and W. L. Kirk\*. Va. Inst. Sci. Res., Richmond, Va. 23229 and Univ. of Richmond, Va. 23173

From January 1973 through March 1974 44 genera of algae (six divisions) were collected during the study of seasonal changes in the size of periphytic populations in a Piedmont section of the James River receiving heated effluent from an electric power station. Sampling was from natural areas and artificial glass-slide substrates. Greatest fluctuations in abundance occurred in blue-green and diatom populations. Blue-greens formed thick mats over most substrates in the thermal plume during the summer when temperatures exceeded 29°C, hence greatly increasing the standing crop. Comparable growths of these forms were never observed during any season in ambient temperature habitats. Diatoms increased in numbers during the warmer season on the unheated side of the river and were most abundant in the heated water during the cold months.

Funds were provided by the United States Department of Interior as authorized under the Water Resources Research Act of 1974 as amended; and by Virginia Electric and Power Company.

APPLICATION OF ERTS IMAGERY AND THE LARS SYSTEM TO VEGETATIONAL MAPPING OF THE DISMAL SWAMP. J.A. Messmore\*, G.E. Copeland, G.F. Levy, and R.A. Blais. Dept. of Biology and Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va. 23508

This study concerns the feasibility of using digital satellite imagery and automatic data processing techniques as a means of mapping forest vegetation. Multispectral scanner data acquired by the Earth Resources Technology Satellite (ERTS-1) was analyzed using ADP techniques developed by Purdue University's Laboratory for Applications of Remote Sensing. The site for this investigation was the Dismal Swamp, a 210,000 acre swamp forest located south of Suffolk, Va. on the Virginia-North Carolina border. Due to inadequate information on the distribution of vegetation within the swamp, an unsupervised classification scheme was utilized. Initially pictureprints, resembling low resolution photographs, were generated in each of the four ERTS-1 channels. Data found within rectangular training fields was then clustered into 13 spectral classes and defined statistically. Using a maximum likelihood classification scheme, the unknown data points were subsequently classified into one of the designated training classes. Training field data was classified with a high degree of accuracy (greater than 95%) and progress is being made towards determining the relationship between the mapped spectral classes and known surface data.

EARLY FOREST SUCCESSION IN THE SOUTHEASTERN VIRGINIA COASTAL PLAIN. Roland Monette. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Nineteen forest stands ranging from 20 to 99 years old were analyzed in the southeastern Coastal Plain of Virginia to determine the succession pattern. The younger stands were dominated by *Pinus taeda* with little *Pinus virginiana* or *Pinus echinata* present. In older stands *Pinus taeda* gave way to *Quercus alba* as leading dominant. *Fagus grandifolia* dominated the oldest stands with *Quercus alba* second in importance. *Acer rubrum* and *Carya tomentosa* were associates in some stands but never became dominant. The high importance of *Fagus grandifolia* and *Quercus alba* in the oldest stands indicates a Beech-White Oak climax.

PIGMENT ANALYSES OF FRUITING STRUCTURES AND MYCELIA IN THE GENUS *ENDOTHIA*. Martha K. Boone, R. Jay Skipes, and John Rush Ekins. Departments of Biology and Plant Pathology/Physiology, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061.

Thin layer chromatography and spectrophotometric scans were applied to organic solvent-extracted pigments from stromal tissues and mycelia of several species of *Endothia*. Comparisons were made with known *Endothia* pigments, oxy-skyrin, rugulosin and skyrin. Species separation by means of these techniques seems to be quite effective.

(We thank the American Philosophical Society for grant-in-aid support)

EFFECTS OF PH ON THE GROWTH, SPORULATION, AND PIGMENTATION OF AN ISOLATE OF *HUMICOLA LANGUINOSA*. William H. Meile\*. Dept. of Biology, Madison College, Harrisonburg, Va. 22801  
*Humicola lanuginosa* (Griffon and Maublanc) Bunce (1961) is a thermophilic Deuteromycetes. The fungus was isolated from hay and maintained by moist chamber techniques at 50 °C.

The effects of pH on the growth, sporulation, and pigmentation of *H. lanuginosa* were investigated. Various carbon and nitrogen sources were used in buffered media with a pH range of 3 through 8. The carbon sources were xylose, glucose, galactose, fructose, sucrose, lactose, melibiose, mannitol, and starch. Nitrogen sources included sodium nitrate, ammonium chloride, asparagine, glycine, aspartic acid, and urea.

Growth, measured by dry weight at the end of a 4 day incubation period, occurred at pH 5 through 8 and was maximal at pH 6 using glucose and asparagine. No growth occurred with galactose, lactose, melibiose, or sodium nitrate.

Visual evaluation indicated sporulation was best using those carbon and nitrogen sources that supported good growth. However, maximal sporulation usually occurred at a slightly higher pH than maximal growth.

The fungus produced a diffusible pigment when grown on carbon and nitrogen sources that supported good growth and sporulation. The degree of pigmentation of the medium was greatly influenced by its pH. Pigmentation appeared to be greater at pH 8 in spite of reduced sporulation and growth, regardless of the carbon and nitrogen sources supplied.

Notes on Fungi from Arctic Litter  
Thomas G. Rau and O.K. Miller Jr.  
Dept. of Biology V.P.I.&S.U. Blacksburg, Va. 24061

Plant litter and fauna excrement were collected from several select arctic habitats on 12 U.S.I.B.P. Tundra Biome sites at Barrow and Cape Simpson which are on the northern coastal plain of the Alaskan North Slope. Three phycocyanobacteria have been isolated. *Mucor hiemalis* was found in all habitats on grasses, sedges and dung of herbivores. *Piptocercaria lepidula* was found as a parasite on *Mucor hiemalis* but not in all habitats. The presence of *Piptocercaria lepidula* in culture seems to be substrate and temperature specific. A second *Mucor*, suspected of being a new species was isolated.

THE HELENIEAE (ASTERACEAE) IN VIRGINIA. Gerald F. Rogers. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185.

The genera comprising the Helenieae in Virginia, *Helenium* (5 species), *Gaillardia* (1 species), and *Tagetes* (1 species) are surveyed systematically. Keys to the genera and species, descriptions, flowering dates, ecological data, and Virginia distribution maps are included. New and interesting information concerning *H. virginicum* is reported.

THE FLORA OF SOUTHEAST NEW KENT COUNTY. Douglas E. Soltis, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23186.

The area studied occupies an approximately eight square mile area of southeast New Kent Co., Va. This area includes the Davis Pond - Goddard Pond drainage system, as well as land bordering the York River.

Collections were made several times a week, beginning on May 29, 1974 and are presently continuing. As of April 23, 1975, a total of 510 taxa, representing 322 genera, of 104 families had been recorded.

Major community types are 1) brackish marsh 2) fresh water marsh 3) pond margins 4) low-lying, predominantly black gum woods 5) upland, mixed oak-hickory woods 6) mature mixed deciduous woods, dominated by beech 7) mixed pine-deciduous woods 8) pine woods 9) old homesites 10) roadsides, fields and disturbed habitats.

CULTIVATION OF THE IMMATURE OVULES OF *Pinus taeda* IN VITRO. E. Wilson, Dept. of Life Sciences, Va. State College, Petersburg, Va. 23803.

Callus was formed from immature ovules of *P. taeda* on Brown and Lawrence's medium containing 0.5mg 2,4,6 per liter and 0.5 mg kinetin per liter. No differentiation has occurred in the cultures on this or any other culture media tried.

THE VEGETATION ALONG PITTS CREEK, ACCOMACK CO., VA. E. S. Wise, Christopher Newport Col., Newport News, Va. 23606 and A. M. Marvill, Jr., Longwood Col., Farmville, Va. 23901.

Pitts Creek flows into Virginia from Worcester County, Md. at Wagram bridge and enters the Pocomoke River about 5 miles below Wagram. Tides from the Pocomoke River affect Pitts Creek to a point above Wagram bridge.

Vegetation along the Pocomoke River near the mouth of Pitts Creek is brackish marsh dominated by *Typha* spp., *Hibiscus moscheutos*, *Pontederia lanceolata*, and *Peltandra virginica*. At and inside the mouth of Pitts Creek there are extensive marshes dominated by *Spartina cynosuroides*.

Further upstream the marshes become narrower and *Typha*, *Hibiscus moscheutos*, *Pontederia lanceolata*, and *Peltandra virginica* become dominant with the latter two species extending into the creek from the marshes. As the creek enters higher terrain the marsh disappears, but rooted aquatic continues, backed by a flood plain with typical swamp tree species continuing to Wagram bridge. A small clump of *Taxodium distichum* is found along the upper part of the creek and at Wagram bridge there are a few scattered individuals of *T. distichum*. *Pinus taeda* grows in the wooded flood plain along with deciduous species, but no *P. serotina* could be found. The vegetation and habitat are unusual for Accomack County, and resemble those of the North Landing River - Northwest River areas of Va.

SOME OBSERVATIONS ON THE DEVELOPMENT OF EUTROPHICATION OF LAKE CHESDIN. E. Woodson, F. Hawthorne, \* J. Mosby, \* and E. Seaburg\*. Dept. of Biology, Va. State Col., Petersburg, Va. 23803.

The study involves chemical analyses, pesticide level determination, and quantitative and qualitative determinations of phytoplankton populations.

Five sampling stations were established at the mouths of tributaries. Three depths were sampled--surface, one and three meters. As the temperature falls, phosphorus content rises, reaching the highest levels in mid-winter. Inorganic nitrogen also increased during the cold months with  $\text{NH}_4\text{N}$  increasing to a greater extent than the oxidized forms. pH values ranged from 6.6 to 8.2 with the highest values in late fall.

Dissolved oxygen remained fairly stable, affected only slightly by warming trends of short duration. Hardness maintained an average value between 12 and 17 mg/l.

The levels of the following chlorinated pesticides were determined: aldrin, dieldrin, endrin, and heptachlor. The levels of total pesticides decreased during the winter period. An increase is expected as agricultural use will be evident during the growing season.

The phytoplankton study has indicated rich growth as relates to productivity and species diversity. Ninety-three species representing fifty-four genera of algae dominated by the class Bacillariophyceae. *Melosira granulata* var. *angustissima* was the dominant species.



## Abstracts of Papers Section of Chemistry

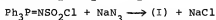
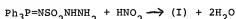
Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

**FLUORESCENCE AND PHOSPHORESCENCE OF CRYSTALLINE BIBENZYL.** R. L. Ake, Dept. of Chemical Sciences, Old Dominion University, Norfolk, Va. 23508

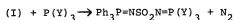
The temperature dependent fluorescence and phosphorescence spectra of crystalline bibenzyl are reported. Lifetimes of phosphorescence and fluorescence/phosphorescence intensity ratios are analyzed in an attempt to decide if intramolecular exciton coupling influences the energy transfer in crystalline bibenzyl. Constancy of phosphorescence lifetime over 20-40K range while phosphorescence quantum yield falls in the same temperature range seems to indicate an exciton influence.

**CHEMISTRY OF (TRIARYLPHOSPHORANYLIDENE) SULFAMOYL CHLORIDES: PREPARATION AND REACTION OF (TRIPHENYLPHOSPHORANYLIDENE) SULFAMOYL AZIDE WITH P(III) COMPOUNDS.** D. E. Arrington, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

(Triphenylphosphoranylidene)sulfamoyl azide,  $\text{Ph}_3\text{P}=\text{NSO}_2\text{N}_3$  (I), may be prepared by the reduction of the hydrazide with nitrous acid or by the reaction of sodium azide with the chloride in suitable solvents:



The azide reacts with phosphines, phosphites, and thiophosphites in an oxidative imination reaction to give phosphinimines in good yields:



Y = alkyl, aryl, OR, SR

The latter reaction does not take place, however, with some thiophosphites and ortho-substituted triarylphosphines; a plausible explanation for this will be presented.

**IMINOSULFURANE REARRANGEMENTS.** R.C. Atkins and C.R. Nelson, Dept. of Chemistry, Madison College, Harrisonburg, Va. 22801

Pyrolytic and photolytic rearrangements of N-toluenesulfonyl iminosulfuranes (sulfilimines) have been studied. Pyrolysis of S,S-dimethyl-N-toluenesulfonyl sulfilimine yields a variety of sulfide and disulfide products. The corresponding diphenyl sulfilimine yields primarily diphenyl sulfide and toluenesulfonamide. Photolysis of the dimethyl sulfilimine at several wavelengths yields toluenesulfonamide as well as considerable recovery of starting material.

Efforts are currently underway to elucidate the mechanisms of the rearrangements being observed.

**ADSORPTION OF HCL ON  $\gamma\text{-Al}_2\text{O}_3$ .** R. R. Bailey\* and J. P. Wightman. Chem. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Studies of the adsorption and desorption of water and hydrogen chloride on  $\gamma\text{-Al}_2\text{O}_3$  were performed at several temperatures and modes of surface pretreatment. The  $\text{H}_2\text{O}$  adsorption was completely reversible, while the HCl showed only some reversibility, an indication of chemisorption. Comparison of the surface area of  $\gamma\text{-Al}_2\text{O}_3$  determined by  $\text{N}_2$ , HCl and  $\text{H}_2\text{O}$  adsorption showed that the adsorption of HCl and  $\text{H}_2\text{O}$  proceeds by interaction of these gases with specific sites on the  $\gamma\text{-Al}_2\text{O}_3$ .

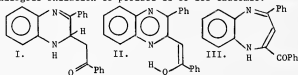
THE LAMINAR-TO-TURBULENT TRANSITION IN THE BOUNDARY LAYERS OF CHEMICAL SHOCK-TUBE FLOWS. John A. Bander and George Sanzone, Department of Chemistry, VPI & SU, Blacksburg, Va. 24061.

It is well-known that shock-tube flows involve periods of both laminar and turbulent boundary layer flow. The implications of this fact have generally been ignored by kineticists in their calculations of shocked-gas temperatures. This is because it has been difficult to predict the fraction of time for which the flow is laminar.

A new theoretical approach for the prediction of contact-front arrival times is presented which allows the determination of this fraction of shock-tube flow time for which a laminar boundary layer obtains. Data taken with a modified laser-schlieren system is used to test the theory.

REACTION OF *o*-PHENYLENE DIAMINE WITH DIBENZOTYLETHYLENE AND DIBENZOTYLACTYLENE. ISOLATION OF A REACTIVE INTERMEDIATE. R. G. Basse\*, D. D. Crichton, Harriet K. Meetz and Ashby F. Johnson, Jr., Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

Equimolar amounts of *cis*- or *trans*-dibenzotylethylene and *o*-phenylenediamine react in refluxing ethanol to yield 2-phenylquinoxaline and acetophenone. Whereas combining equimolar amounts of *o*-phenylenediamine and dibenzotylethylene in 95% ethanol and warming (50°) to effect solution followed by cooling produced a new substance shown to be I. Compound I is quite sensitive and in refluxing 95% ethanol, it is converted quantitatively to 2-phenylquinoxaline and acetophenone. On standing in the solid state for a period of 4-6 weeks, I undergoes oxidation to produce II or its tautomer.



Compound II proved to be identical with the product formed by reaction of *o*-phenylenediamine with dibenzotylethanol or with dibenzotylactylene. Compound II had previously been reported to be 2-benzoyl-4-phenyl, (1H), 5-benzodiazepine (III).

THE USE OF THE COMPUTER AS A PRACTICE AID IN GENERAL CHEMISTRY. James D. Beck, Department of Chemistry, Virginia State College, Petersburg, Va. 23803

The installation of an IBM System 370/125 computer at Virginia State College has allowed the use of remote terminals in a time-shared mode. BASIC and Coursewriter (a language designed for computer-assisted instruction) are available for use on the interactive terminals. A number of simple programs have been written in BASIC for use by students in General Chemistry. These programs are intended to introduce students to the use of the computer and to provide practice on a few fundamental concepts. Some of the experiences of a novice programmer will be recounted. Preliminary experience with Coursewriter and some possibilities for computer-generated problem sets will be discussed.

GROUP THEORY AND REACTION MECHANISMS: PREDICTIONS AND COMPUTATIONS ON  $C_2H_5^+$ . Thomas D. Bouman, Charles D. Duncan, and Carl Trindle, Chemistry Dept., Univ. of Va., Charlottesville, Va. 22901

Melver's rules on the symmetry of transition states have a counterpart in rules concerning permutation symmetry of single steps in degenerate rearrangements. The generalized rules are illustrated by the  $PK_3$  polytopal rearrangements and fluxional motions of organometallics. The analysis leads to prediction of hitherto unexplored "pseudo rotation" pathways for rearrangements in  $C_2H_5$  and  $C_2H_5$  cations. CNDO computations of system energies, gradients and curvatures at critical points on the  $C_2H_5$  surface indicate that symmetry breaking in keeping with our predictions is a key feature of the low energy rearrangements of these species. In particular, computation shows that the  $C_{2v}$  "homotetrahedral" species is at an energy maximum and, thus, cannot be a transition state as proposed earlier.

DIGITAL INTEGRATOR FOR FLAMELESS ATOMIC ABSORPTION ANALYSES. G. R. Conner\* and G. C. Grant, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

In atomic absorption spectrophotometry recent developments in flameless atomization such as the tantalum ribbon, L'vov furnace, Delvac cup, Massman furnace and carbon rod have produced transient rather than steady-state atom populations. The resulting peak absorbance signal is most commonly monitored with a laboratory recorder. Various factors can effect the shape of the peak, thus implying that peak area measurements are more desirable than peak height. A stand-alone integrator was constructed to be automatically controlled by the flameless unit, and the peak area is displayed on an auto-ranging digital panelmeter. Automatic reset and switch selectable integration intervals are controlled by a precision timing circuit with analog FET switches.

AMBIENT CONCENTRATIONS OF MEDIUM WEIGHT HYDROCARBONS ( $C_5$  TO  $C_{10}$ ) IN THE DISMAL SWAMP ATMOSPHERE. R. S. Davis, P. J. Maroulis, A. R. Bandy, Department of Chemistry and G. E. Copeland, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

During the late spring of 1974, air samples were taken in the Dismal Swamp and Nansemond areas of the Tidewater area to determine the naturally generated hydrocarbon contribution to the lower atmosphere. The samples were analyzed for the  $C_5$  to  $C_{10}$  hydrocarbons using a flame ionization gas chromatograph. Analysis of the data indicates an average concentration of 397 ppb by weight of the compounds analyzed. This value exceeds the National Primary Air Quality Standards. The largest class of compounds was the paraffin group. The biggest individual contributor was cyclopentane.

**ALTERNATIVE POSTGRADUATE CAREERS FOR CHEMISTRY MAJORS.** A. J. Diefenderfer, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508  
Traditionally, graduates from most B.S. (and B.A.) programs in chemistry have found a relatively limited employment opportunity. With the seemingly decreased interest in traditionally trained doctoral candidates, it is imperative that a viable alternative be developed. A revitalized M.S. in chemistry is an obvious way to weld student and employer interest. The Chemical Sciences Department of ODU has developed program areas in Chemical Instrumentation, Clinical Chemistry, Environmental Chemistry, Forensic Chemistry and Toxicology. These M.S. specialization areas are offered in conjunction with practical experience opportunities.

**CHEMICAL EVIDENCE OF MANS INTRUSION INTO THE DISMAL SWAMP ECOSYSTEM.** A. J. Diefenderfer, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

The principle use of chemical information concerning the Dismal Swamp has been in support of biological and/or geological descriptions. Until recently, little effort has been directed toward the acquisition of chemical analyses which indicated the extent of intrusion of the industrial society surrounding the area. Data will be presented which indicate that the process is underway. While no immediate remedial action is suggested, these data provide base-lines by which future changes may be compared. Refinements of precise analytical techniques may yield a clearer description of certain biological and/or geological processes as well.

#### SOME STUDIES ON PEROXO EDTA NIOBATES.

C. Djordjevic, N. Vuletic\*, and W. T. Barnes\*. Dept. of Chemistry, The College of William and Mary, Williamsburg, Va. 23185

A bidentate peroxo group in the tetraperoxo niobates can be substituted by an EDTA ligand. Complexes of the formula  $M(1), [Nb(O)_2(EDTA)H_2O]$ , have been obtained. These are stable crystalline substances and the molar conductivity of the aqueous solutions implies the presence of a 3:1 electrolyte. The IR spectra are complex, but some characteristic frequencies indicate the presence of coordinated peroxo groups and the coordination of the carboxylate groups of EDTA. Preliminary experiments have been done in aqueous solutions, where NMR spectra show the presence of coordinated EDTA.

Preparation of some other salts of this new series of mixed-ligand peroxo complexes has been attempted. The calcium salt was obtained, probably corresponding to the formula  $KCa[Nb(O)_2(EDTA) \cdot H_2O]$ . This salt is unfortunately not soluble enough to permit proper purification and other routine solution work. Further studies are in progress.

**STRUCTURE REACTIVITY CORRELATIONS FOR COLLAPSE OF N-P-CHLOROBENZYLIDENEANILINE ADDUCTS.** Dana Donatucci\*, and John P. Fox. Dept. Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Nonlinear structure reactivity correlations for hydronium ion catalyzed reactions of N-p-chlorobenzylideneanilines with substituted anilines indicate a gem-diamine adduct is formed as a kinetically significant intermediate in transimination reactions of weakly basic amines. Logarithms of rate constants for reaction of substituted anilines with N-p-chlorobenzylidene-m-nitroaniline plotted against pK are biphasic with slopes 1.1 and 0.45 for anilines of  $pK < pK$  m-nitroaniline and  $pK > pK$  m-nitroaniline, respectively. Imidazole adducts of N-p-chlorobenzylideneanilines substituted in the aniline moiety have been prepared. Logarithms of rate constants for hydronium ion catalyzed collapse of adducts are well correlated against the pK of the aniline moiety with slope 0.65. Rate limiting steps in transimination reactions which are dependent upon the relative basicity of attacking and leaving groups are tentatively assigned. (Supported by ACS-PRP Grant 7691-AC4)

#### THE CHROMATOGRAPHIC SEPARATION OF METAL IONS.

D. M. Downey\*, F. A. Palocsay and J. J. Leary, Dept. of Chemistry, Madison College, Harrisonburg, Va. 22801

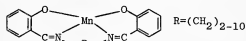
Alizarin Red S [Sodium Alizarin Sulfonate] was used for the nonspecific colorimetric detection of lanthanides eluting from a cation exchange column. Competition between the eluant (citrate buffer) and the Alizarin Red S for the metal ions was observed. This competition necessitated the use of rather large samples ( $10^{-4}$  moles).

Lead and zinc were also separated via cation exchange chromatography using 1.5 M nitric acid as the mobile phase and dithizone in 4 M NaOH as the colorimetric reagent. The complexes formed were monitored at 540 nm where both metal complexes have large extinction coefficients.

A high pressure liquid chromatograph has been built. Its construction will be discussed as will its applications to metal ion separations.

**MANGANESE-OXYGEN COMPLEXES.** S. J. Ebbs, W. M. Barr and L. T. Taylor, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The preparation of manganese (II) complexes employing tetradentate Schiff base ligands derived from various substituted alicyclic aldehydes and polymethylenediamines will be described. Complexes of general formula  $Mn(II)(C_2H_5O)_x$  (Structure I) where  $x=0$  or 1 have been isolated and characterized employing elemental analyses, mass spectra, UV-Vis-IR spectra and magnetic susceptibility. The tendency of these new materials to undergo oxygenation appears to



STRUCTURE 1

increase as the methylene carbon chain increases in length. Complexes employing ligands where  $R=C_6-C_{10}$  readily oxygenate in the solid state to give dark red-brown manganese-oxygen bound species as evidenced by their infrared spectra. Similar materials are obtained when these same precursors suspended in DMSO are exposed to oxygen. Oxygen up-take data coupled with thermal gravimetric weight loss experiments suggest a Mn:O ratio of 1:1. The application of x-ray photoelectron spectroscopy in order to ascertain the oxidation states of manganese and oxygen in the oxygen adducts will be explored.

CALIBRATION TECHNIQUES FOR ATMOSPHERIC OZONE MONITORS. H. M. Finley, A. R. Bandy, Department of Chemistry and G. E. Copeland, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

The Federal Reference Method for photochemical oxidants specified in regulations on National Primary and Secondary Ambient Air Quality Standards is based on the chemiluminescence resulting from the reaction of ozone with ethylene. The method is calibrated by measuring synthetically prepared standard atmospheres of ozone and developing a method response versus ozone concentration curve. The concentration of ozone in the standard atmospheres used for calibration is determined by using the one percent neutral buffered potassium iodide procedure as specified in the regulations appearing in the *Federal Register* 36(228): 22384-22397, November 25, 1971.

Although the one percent neutral buffered potassium iodide procedure has been in use for quite some time, it has been widely criticized for its inconsistent and non-reproducible results.

A LOW COST TEMPERATURE PROGRAMMER. T.N. Gallaher, F.A. Palocay, and R.C. Atkins, Dept. of Chemistry, Madison College, Harrisonburg, Va. 22801

A low cost temperature programmer, for use in gas chromatography, using digital control circuitry, a stepper motor, and a variable resistor is described.

Commercial programmers are available at prices ranging from \$600 to \$1500. The linear temperature programmer described was built for less than \$60 in materials. Results obtained indicate linear temperature control over a continuously variable range of programmed rates up to 15°C/min.

AMBIENT CONCENTRATIONS OF LOW MOLECULAR HYDROCARBONS ( $C_1$  TO  $C_5$ ) IN THE TIDEWATER ATMOSPHERE. D. Hausler, A. R. Bandy, Department of Chemistry and G. E. Copeland, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

The EPA regulations require the control of vehicular hydrocarbon emissions during the critical periods of high oxidant concentrations by limiting the amount of traffic flow. It is essential that the sources of hydrocarbons be established and their overall importance to the scheme of oxidant control be ascertained. Low molecular weight hydrocarbons ( $C_1$  to  $C_5$ ) have been utilized in the past to characterize some of the sources of ambient levels of hydrocarbons. Acetylene, carbon monoxide, and acetylene ratios have been suggested as tracers for ambient concentrations of vehicularly developed hydrocarbons. The establishment of a gas chromatographic method utilizing subsambient temperature trapping for the detection of hydrocarbons in the PPB range and the ambient levels of acetylene with subsequent acetylene/specific hydrocarbon ratio will be discussed.

STUDIES IN THE OXIDATION OF  $\Delta^9,10$ OCTALIN

F.J. Heldrich III, R.G. Lloyd, T.A. Mickler Jr., J.K. Shillington, E.W. Stradtman Jr., M.W. White  
Dept. of Chemistry W & L Univ. Lexington, Va. 24450

A study of the oxidation of the mixed isomers of  $\Delta^9,10$  octalin by rapid oxidation with performic acid generated *in situ* from hydrogen peroxide and formic acid was undertaken. The reaction was run in small quantities since it is highly exothermic and difficult to control. The hydroxyferoxy derivative was isolated at this point as crude solid which was used without purification in the saponification step. Saponification lead to a white crude solid and was purified by vacuum distillation. This diol was oxidized with lead tetracetate to cyclodecane-1,6-dione.

GAS CHROMATOGRAPHIC STUDIES OF ADSORPTION AND PARTITION OF NONPOLAR SOLUTES WITH AQUEOUS SODIUM CHLORIDE SOLUTION. J. M. King\*. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

Adsorption and partition coefficients have been determined by gas chromatography for twenty-six nonelectrolytes adsorbing and partitioning into aqueous sodium chloride solutions of varying ionic strength. Excellent agreement is obtained between adsorption coefficients determined by static methods and the chromatographically-derived values, indicating the validity of the assumptions used in making the chromatographic measurement. The adsorption coefficients for all the nonelectrolytes initially decrease with sodium chloride concentration to a minimum value between 0.4-0.5 molar sodium chloride concentration. This trend is reversed at higher electrolyte concentrations up to 5.3 molar. A constant logarithmic incremental change in the adsorption coefficient for members of a homologous series of nonelectrolytes indicates the applicability of Traube's Rule to ionic solution interfaces. Partition coefficients for soluble nonelectrolytes decrease with increasing electrolyte concentration, indicating the presence of the "salting-out" effect. Good agreement is obtained between experimentally determined salting out constants and available literature values. Surface and bulk activity coefficients are found to be consistent with increasing adsorbability of the nonelectrolyte at that solution/gas interface as a function of salt concentration.

INFLUENCE OF ADDED ELECTROLYTE TO THE STATIONARY PHASE ON RETENTION AND SELECTIVITY IN GAS-LIQUID CHROMATOGRAPHY. J. M. King\*. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

The effect of electrolyte addition to the stationary phase in gas chromatography on the net retention volume,  $V_N^0$ , and relative retention of injected solutes has been determined. The observed trends for these two variables show the contribution of both singular and dual retention mechanisms to solute migration in the chromatographic column. Results for n-alkane and 1-alkene solutes on aqueous NaCl and CaCl<sub>2</sub> solutions indicate a large linear increase in the  $V_N^0$  as the % loading of the stationary phase is decreased, however, no change is noted in the relative retention of the above solutes. Trends in  $V_N^0$  and relative retention for aromatic and halogenated hydrocarbons are complex, indicating retention by a dual sorption mechanism. Inversion in relative retention is observed for the latter solute class. Finally, the effect of solute interfacial adsorption at the gas-liquid interface and its dependence on additive concentration will be discussed with respect to the determination of complexation constants by gas chromatography.

NUCLEAR MAGNETIC RESONANCE STUDIES OF THE STEREOCHEMISTRY AND LABILITY OF METAL- $\beta$ -DIKETONATE COMPLEXES. D. E. Kranbuehl, P. Metzger, D. H. Thompson, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

With the increase in sophistication and cost of current instrumental techniques, it is becoming increasingly difficult in the undergraduate program to provide students with "hands-on" exercises in solving chemical problems. Yet the desirability of acquainting students with important new problem-solving techniques is indisputable. A partial solution to this problem is the use of interpretative experiments. This paper discusses an interpretative experiment involving the application of symmetry and temperature dependent proton and fluorine nmr spectroscopy to the solution of structural and mechanistic problems in titanium- $\beta$ -diketonate complexes. Concepts to which students are exposed include: (1) the application of molecular symmetry to predict nmr patterns; (2) stereochemical non-rigidity of complexes; (3) the use of nmr techniques to determine structure in complexes; (4) the use of nmr line shape analysis to determine kinetic data.

ZIRCONIUM-CYANOACETYLACETONATE COMPLEXES. G. A. Lock\* and D. W. Thompson. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

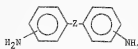
The reaction of  $\text{SnCl}_4$  and  $\text{TiCl}_4$  with cyanoacetylacetone (CAAH) in inert organic solvents leads to  $[\text{MCl}_2(\text{CAA})_2]$  complexes. The ir spectra are consistent with the CAA anion exhibiting trifunctional metal bonding via both oxygens and the cyanide group. Since the CAA anion is planar, the complexes must be oligomerized,  $[\text{MCl}_2(\text{CAA})_2]_n$ , a cyclic tetramer has been postulated. Extending this work to  $\text{ZrCl}_4$  yielded different results. Reaction of  $\text{ZrCl}_4$  and CAAH in a 1:1 molar ratio did not yield a discrete  $[\text{ZrCl}_2(\text{CAA})_2]$  complex. Rather  $[\text{ZrCl}_2(\text{CAA})_2]_n$  is isolated. While the complex is stoichiometrically analogous to the six-coordinate acetylacetonate analog, the ir spectrum indicates both bridging and terminal cyanide groups with all O-chelated diketonates. Thus an oligomerized structure seems likely. Careful treatment of other  $\text{ZrCl}_4$ -CAAH systems yields complexes  $[\text{ZrCl}_2(\text{CAA})_2]_n$  and  $[\text{Zr}(\text{CAA})_4]_n$ . Again in  $[\text{ZrCl}_2(\text{CAA})_2]_n$  both bridging and terminal cyanide groups are observed. For  $[\text{Zr}(\text{CAA})_4]_n$  only terminal cyanide groups are observed consistent with a maximum CN=8 for Zr.  $[\text{Cp}_2\text{Zr}(\text{CAA})_2]$  shows only terminal cyanides and is seven coordinate.

AN EXTENSION OF THE MIXED BED COLUMN TECHNIQUE IN GAS CHROMATOGRAPHY. D. F. Lynch, F. A. Palocsay and J. J. Leary, Dept. of Chemistry, Madison College, Harrisonburg, Va. 22801

Mixed bed columns were prepared using dimethylsilicone and phenylmethylsilicone homopolymers. The retention behavior of the mixed bed columns was compared to that of phenylmethylsilicone copolymer columns containing the same average weight-percent phenyl substitution. Kovats Indices were used to evaluate retention behavior. Mixed bed columns and copolymer columns were shown to have very similar retention characteristics. The average percent difference in Kovats' Index units was 0.5%.

THE POTENTIOMETRIC EVALUATION OF THE BASICITIES OF AROMATIC DIAMINES IN 90% ACETONITRILE - 10% WATER MIXTURES. J. G. Mason and C. Potter, Dept. of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

The basicities of a series of aromatic diamines of the general formula



where  $Z = O, >C=O$ , and  $>CH_2$  have been determined in 90% acetonitrile-10% water mixtures, dimethylacetamide- and dimethylsulfoxide. The technique used was titration with perchloric acid solution as titrant and a carefully calibrated glass electrode as sensor. The solvent mixture 90%  $\text{CH}_3\text{CN}$ -10%  $\text{H}_2\text{O}$  permitted the resolution of both  $\text{pK}$  values in certain cases and was the most suitable differentiating solvent system. The glass electrode response was found to be reproducible but not theoretical. The  $\text{pK}$  values of nineteen diamines have been determined by this method.

DETERMINATION OF GLUCOSE IN TOBACCO LEAF AND COMMERCIAL FILLER BY GLUCOSE OXIDASE. Barbara M. McIntyre, Philip Morris Research Center, P.O. Box 26583, Richmond, VA 23261.

An adaptation of procedures found in the literature pertaining to the rapid and specific colorimetric determination of glucose in tobacco leaf and commercial filler is presented. The analysis is performed on a water extract treated with carbon. In the presence of the enzyme glucose oxidase, a colored complex is formed. The samples are compared with glucose standards on the Robot Chemist using a 540-nm filter. The relative standard deviation at the two-sigma level on a bright tobacco Monitor is  $\pm 9\%$  and on a commercial filler is  $\pm 7\%$ . Recoveries of added glucose in burley tobacco average 99%.

THE EFFECT OF DENSITY ON THE DYNAMIC PROPERTIES OF MONTE CARLO LATTICE MODEL POLYMER CHAINS. R Metzger and D. Kranbuehl, Dept. of Chemistry, the College of William and Mary, Williamsburg, Va. 23185

The dynamic and equilibrium properties of several random-coil polymer chains confined to a box have been simulated using Monte Carlo techniques. In this model the configurations of the polymer chain,  $N-1$  units long, are represented by a string of  $N$  connected points, referred to as beads, on a simple cubic lattice. Brownian motion of the chain is simulated by choosing one bead at a time and moving it to a new position. Excluded volume is accounted for by not allowing two beads to occupy the same lattice site. The relaxation behavior of the vector end-to-end length was examined for polymer chains confined to a fixed volume in which the bead density is allowed to vary. It was found that as the density increases the equilibrium value of the vector end-to-end length approaches the theta conditions and the relaxation spectrum becomes bimodal.

AN INEXPENSIVE DIGITAL MULTIMETER TO COMPUTER INTERFACE. C.R. Nelson and F.A. Palocsay, Dept. of Chemistry, Madison College, Harrisonburg, Va. 22801

An interface between a digital multimeter and minicomputer is described. The interface uses an Analog Devices STX 1003 serial data exchange module to convert binary-coded-decimal output to serial transmission acceptable to a computer. A variable sample clock is used to control the rate of data collection.

#### THE STEREOCHEMISTRY OF THE ENZYME-CATALYZED REDUCTION OF A PROGESTERONE DERIVATIVE.

C. A. Risinger\* and O. R. Rodig, Dept. of Chemistry, Univ. of Va., Charlottesville, VA 22901.

*Rhizopus nigricans*, a common bread mold, has the ability to microbiologically transform 16-dehydropregesterone to 11 $\alpha$ -hydroxypregesterone. We were interested in studying the mechanism of the reduction of the 16,17 double bond and for this purpose it was necessary to synthesize 16-dehydropregesterone-16-d<sub>1</sub>. The starting material, testosterone, was converted by a six-step route to the appropriate deuterated compound. In carrying out the enzyme-catalyzed reduction, the 16-dehydropregesterone-d<sub>1</sub>, dissolved in acetone, is added to a growing culture of the microorganism in a liquid medium. After shaking for 72 hours the transformed steroid is recovered from the medium and the mycelium by extraction and the purified product analyzed by NMR using the lanthanide shift technique. By comparing the spectra of deuterated and non-deuterated 11 $\alpha$ -hydroxypregesterone, the stereochemistry of the deuterium at the 16 position can be determined.

#### ENZYME-CATALYZED TRANSFORMATIONS OF STEROIDS. THE STEREOCHEMISTRY OF A DEHYDROGENATION REACTION. A. W. Nicholas\* and O. R. Rodig, Dept. of Chemistry, Univ. of Va., Charlottesville, VA 22901.

A number of important steroid hormone drugs contain a C-1, C-2 double bond, usually synthetically introduced, which enhance their effectiveness. We have studied the introduction of this double bond by an enzyme-catalyzed dehydrogenation using various microorganisms as an enzyme source. It was determined that the dehydrogenation process involves the *trans*-diaxial loss of hydrogen in each of the six microorganism systems investigated. Suitably labeled deuterium compounds were prepared by selective hydrogenation procedures and the dehydrogenation products were analyzed for the amount and location of the deuterium by NMR spectroscopy.

Two of the microorganisms investigated also contain enzyme systems capable of reducing C-1, C-2 steroidal double bonds if grown under other conditions and in these cases it was found that a *trans*-diaxial addition of hydrogen occurs. Possible mechanisms for both enzyme-catalyzed reactions are considered.

#### SYNTHESIS AND HYDROLYSIS OF ALLENYL ESTERS.

M. D. Schiavelli, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

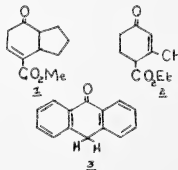
The synthesis of 3,3-dimethylallyl acetates, trifluoroacetates, p-nitrobenzoates, 3,5-dinitrobenzoates, and diethylphosphates from the Ag<sup>+</sup> catalyzed rearrangement in CH<sub>2</sub>Cl<sub>2</sub> of the corresponding propargyl esters is described. Mechanistic data concerning the acid-catalyzed hydrolysis of substituted allenyl acetates is reported. Acidity dependence (linear H<sub>0</sub> plots), substituent effects, and solvent isotope effects consistent with rate-limiting protonation of the allene moiety are discussed. The reaction is compared to vinyl ester hydrolysis.

#### NATURAL ORBITAL CONFIGURATION INTERACTION ANALYSIS OF THE INTERACTION BETWEEN He AND LiH (LINEAR APPROACH). D. D. Shillady and E. Yurtsever\*, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

A large-scale *ab initio* configuration interaction (CI) was carried out for He-LiH using a Dunning-Buzinaga 95,5P plus polarization gaussian lobe basis set. Perturbation treatment of 592 excited configurations with the dominant configuration allowed generation of pseudo-natural orbitals and selection of the 35 most important configurations in the total ground state. Separate CI natural orbital calculations produced an energy of -2.894988 au for He and -8.027838 au for LiH with a dipole moment of 5.818 Debyes. Energy and dipole moment calculations were carried out varying the He-LiH distance at 5 values ranging from 2.4 to 25.0 Bohr with the LiH bond length fixed at 3.015 Bohr. We find a shallow bound state potential in the SCF results in agreement with Kaufman and Sachs (J. Chem. Phys. 31, 2992, (1969)), but our CI energies are much lower and predict a totally repulsive potential. Thus bonding predicted by *ab initio* SCF calculations has been nullified by refined CI computations.

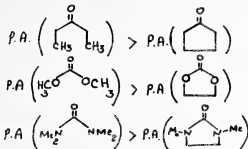
#### DYE SENSITIZED PHOTOOXIDATION OF 5-CARBOMETHOXYBICYCLO [3.3.0] 4-NONENE-2-ONE, 4-CARBOETHOXY-3-METHYL-2-CYCLOHEXENONE AND ANTHRONE. Junaid Siddiqui, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

The dye sensitized photooxidation of 5-carbomethoxybicyclo [3.3.0] 4-nonene-2-one (1), 4-carbomethoxy-3-methyl-2-cyclohexenone (2) and anthrone (3) were studied. Product analysis indicates that the singlet oxygen adds to the enolic homonuclear diene to form corresponding hydroperoxide. The mechanism of this reaction will be discussed.



COMPARISON OF THE PROTON AFFINITIES OF ACYCLIC KETONES, ESTERS, THIOESTER, UREAS, CARBONATES VERSUS THEIR CYCLIC ANALOGUES USING ICR MASS SPECTROMETRY. Junaid Siddiqui, Dept. of Chemistry, Va. Commonwealth University, Richmond, Va. 23284 and Fred Kaplan, Dept. of Chemistry, Univ. of Cincinnati, Cincinnati, OH 45221

Relative proton affinities of several acyclic ketones, carbonates and substituted ureas versus their cyclic counterparts were determined by using ion cyclotron resonance (ICR) techniques. The experiments indicate that acyclic ketones, carbonates and substituted ureas are more basic than their cyclic analogues. The results are attributed to steric effects and changes in hybridization in carbonyl carbon.



SOLVENT ASSISTANCE IN THE SOLVOLYSIS OF BROMO-ALLENES. J. W. Stubbs\* and M. D. Schiavelli, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

Continuing work on the mechanism of haloallene solvolysis is reported. The solvent dependence of  $\alpha$ - and  $\beta$ -secondary isotope effects, the  $\text{CH}_3/\text{H}$  rate ratio and the use of model compounds is discussed. Both  $\alpha$ - and  $\beta$ -isotope effects show no detectable dependence on solvent nucleophilicity other than that expected from studies on  $t$ -alkyl halides. The data are interpreted in terms of a limiting mechanism of solvolysis complicated by rate-determining elimination from a tight ion pair. Recent work on the effect of added salts is also discussed.

STUDIES OF THE VOLUMES OF THE LIQUID-CRYSTAL FORMING 4,4'-DI- $n$ -ALKYLOXYBENZENES. Richard M. Stimpfle\* and Robert A. Orwoll, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

The 4,4'-di- $n$ -alkoxyazobenzene derivatives are members of a class of compounds which can exist in one or more thermodynamically stable states between the melting point of the crystalline solid and the freezing temperature of the normal isotropic liquid. The intermediate mesophase (the so-called liquid crystalline region) retains much of the order characteristic of the crystal and yet exhibits the fluidity of a viscous liquid. This behavior is attributed to a relatively long and rigid molecular structure.

The thermal expansion coefficients and the volume changes accompanying phase transitions have been measured for the methoxy, pentyloxy, and heptyloxy homologs of the 4,4'-di- $n$ -alkoxyazobenzene derivatives above their crystalline melting points. A thermostated dilatometer of special design yielded data of high precision. Rapid increases in the thermal expansion coefficient of the mesophase begin ca  $10^\circ$  below the transition to the isotropic liquid were found. Similar pretransition effects have been observed in calorimetric and other studies. Relatively small (<0.5%) volume changes were measured for the transition from the mesophase to the isotropic liquid.

THE PRODUCTION OF  $^{45}\text{Ca}$  FROM THE ISOTOPES OF TITANIUM. D. P. Swauger\* and R. L. Kiefer, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

Cross sections for the production of  $^{45}\text{Ca}$  from  $^{46}\text{Ti}$ ,  $^{47}\text{Ti}$ , and  $^{48}\text{Ti}$  were experimentally measured using 350 MeV protons. This project was performed in order to determine if the direct knockout of  $^4\text{He}$  clusters contributes significantly to the intermediate energy reaction cross sections of these medium weight nuclei. The cross sections show a significant increase at the  $^{46}\text{Ti}$  and  $^{47}\text{Ti}$  isotopes, showing that the reactions ( $p, p^4\text{He}$ ) and ( $p, pn^4\text{He}$ ) are probably contributing to the measured cross sections.

EXPERIMENTAL TESTS OF THE THEORY OF IFF TIME-OF-FLIGHT MASS SPECTROMETRY. W. A. Thomas, R. Miller and G. Sanzone, Dept. of Chemistry, VPI & SU, Blacksburg, Va.

Recently a new theory of focussing the Time-of-Flight Mass Spectrometer was reported which promised unit mass resolution to 4000. The focus is induced by an impulsive, time-dependent ion draw-out field. This paper reviews the theory of Impulse Field Focussing, discusses calculations on peak shape, and reports on experimental progress to date. The application of IFF to the measurement of initial translational energies of ions is also discussed.

DIELECTRIC RELAXATION PROPERTIES OF NITROAROMATIC  $o$ -TERPHENYL SOLUTIONS IN THE SUPERCOOLED LIQUID STATE. K. Trimmer and D. Kranbuehl, Dept. of Chemistry, The College of William and Mary, Williamsburg, Va. 23185.

Experimental measurements of the dielectric behavior of nitroaromatics in dilute solution with  $o$ -terphenyl at supercooled liquid temperatures have been made. Measurements were made with a General Radio 1615A Capacitance Bridge and a Balesbaugh LD-3 three terminal capacitance cell over a frequency range of 100 to 50,000 Hz and a temperature range of  $-20$  to  $0^\circ\text{C}$ . The relaxation behavior of these molecules is bimodal in the supercooled liquid state and the principle mode of relaxation is the low frequency  $\alpha$  process. This mode of relaxation appears to involve the cooperative motion of the solvent molecules as the magnitude and temperature dependence of the  $\alpha$  process are independent of the size and shape of the polar solute molecule and approximately equal to that of the slightly polar  $o$ -terphenyl solvent.

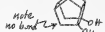
SPECTROELECTROCHEMICAL OXIDATIONS OF METHYLATED XANTHINES, R. A. West and G. C. Grant, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

The electrochemical oxidations of 1,3-dimethylxanthine (theophylline), 3,7-dimethylxanthine (theobromine) and 1,3,7-trimethylxanthine (caffeine) were studied by cyclic voltammetry and potential step experiments in acetonitrile at a reflecting platinum electrode. Theophylline shows only one oxidation peak at 1.37 V vs SCE, while caffeine and theobromine identically show two oxidation peaks at 1.62 V and 1.84 V vs SCE. Comparison of peak shapes at various sweep rates implies that all three compounds undergo an irreversible electrochemical oxidation with  $\alpha_n = 0.64$  ( $\alpha = 0.64$ ,  $n_1 = 1$ ) for caffeine and theobromine and  $\alpha_n = 0.90$  ( $\alpha = 0.45$ ,  $n_2 = 2$ ) for theophylline. In addition, the values of  $(p/\sqrt{v})_{CA}$  decrease by a factor of two for caffeine and theobromine as the sweep rate is increased from 0.5 V/sec. to 2.0 V/sec., however, for theophylline  $(p/\sqrt{v})_{CA}$  remains at the higher level over the same sweep range.

A microcomputer based data acquisition system was constructed and used to simultaneously monitor the changes in absorbance and Faradaic currents during potential step experiments. Transient (approx. 5 seconds) absorption bands ( $\lambda_{max} = 305$  nm) were observed during the electrochemical oxidations of each compound; however, no absorption band of wavelength greater than 280 nm was observed after complete electrolysis of the starting materials.

ORGANIC CAGE COMPOUNDS. G. S. Whitney and L. Hobbes, Dept. of Chemistry, Washington and Lee University, Lexington, Va. 24450

We have carried out reduction and addition reactions on the cage diketone which was formed by radiation of the adduct of cyclopentadiene and quinone.



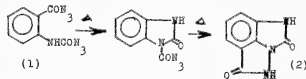
In attempting to make a pinacol product, we found that the bond at the bottom of the cage, alpha to both carbonyls could be broken first, and then the diol could be had under Clemmensen conditions.

We have also attempted to create the diepoxy cage derivative using  $(CH_3)_2S_2O_8$ .



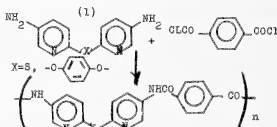
THERMAL TRANSFORMATIONS OF ACYLAZIDES. R. L. Williams, A. Ciereszko and G. Williams, Dept. of Chemistry, Old Dominion University, Norfolk, Virginia, 23508.

Various thermal transformations of the parent carbamoylacylazide (1) will be described together with pertinent spectral and analytical data leading to the structural assignment for the final rearrangement product, the imidazolidazine (2).



HETEROCYCLOIC POLYAMIDES CONTAINING BIPYRIDYL UNITS. R. L. Williams and K. Tant, Dept. of Chemistry, Old Dominion University, Norfolk, Virginia, 23508

Several new, heterocyclic polyamides have been prepared by the condensation of various bipyridyl diamines such as (1) and aromatic diacid chlorides. The resulting polyamide systems will be described with particular attention being given to their relative solubility properties.



SOME 'BASIC' IN CHEMISTRY. John H. Wise and J. Brown Goehring. Dept. of Chemistry, Washington and Lee Univ., Lexington, Va. 24450.

The BASIC language is introduced into the Freshman year course by way of prepared programs for experimental calculations and a problem assignment. One full laboratory period is devoted to instruction in the language in preparation for the problem work. Copies of these class notes are available from the authors. The aim of this instruction is to encourage students to use the computer throughout their course work, but particularly in problem solving. Later courses refer to computer possibilities and often solutions of home-work problems are presented in the form of computer output.

A variety of programs -- including games, some mathematical routines, and a number of chemical applications -- is available for student use. One tutorial program on molecular shape from numbers of electron pairs will be in use next year, and additional tutorials may be added later.

INEXPENSIVE COMPUTER INTERFACING FOR CHEMISTRY LABORATORIES USING PROGRAMMABLE CALCULATORS. James E. Morsham, Jr. Dept. of Chemistry, Univ. of Richmond, Va. 23173

The purpose of this work is to develop simple systems costing less than \$5,000 for on-line data collection and computing from a wide variety of instruments.

The availability in recent years of relatively inexpensive desk size programmable calculators that can be interfaced to voltmeters and other meters has made it possible to introduce on line data collection and computation into undergraduate teaching laboratories. We are using a Wang Laboratories Model 600 programmable calculator with interfaces to a Weston 123 digital multimeter, an Analog Devices digital panel meter and/or a frequency meter-event counter made in our laboratory. To date we have connected this system to Physical Chemistry experiments on emf of electrochemical cells and to the decomposition of ammonium carbonate as a function of temperature. In the latter case thermometers and a resistance pressure transducer provided inexpensive transducers. Two types of other equipment well suited for these functions are Hewlett-Packard Model 9810 and others and Tektronix programmable calculators.

The very recent availability of Sordex modules from Analog Devices permits interfacing through Teletypes used as remote terminals to time sharing computers. We will be investigating these systems soon.



## Abstracts of Papers

### Section of Education

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

A STUDY OF SOCIAL VS. UNION MODEL APPROACH TO IMPROVE THE 'OPEN' PHYSICS LABORATORY AT VPI & SU. Lubna R. Ijaz, Division of Science Curriculum Research and Evaluation, College of Education, VPI & SU; D. C. Denning\*, M. A. Ijaz\*, D. A. Jenkins, and T. E. Leinhardt, Physics Department VPI & SU, Blacksburg, Virginia 24061

This study was designed to investigate the effect of student involvement in designing the laboratory experiment instruction sheets. In the social model approach students, laboratory instructors, laboratory coordinators, administrators and evaluators were involved in making decisions on how to rewrite and revise the presently used instruction sheets. In the union approach the physics faculty and administrators put together the instructional material, without explaining the learning objectives and theory behind the experiment in a way that is easily understandable to all students. With the student input we are able to redesign some instructional material which is more readily understandable to students of all ability levels. Preliminary results on evaluation of this aspect of our laboratory program will be presented.

## Section of Engineering

Fifty-third Annual Meeting of the Virginia

Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

A FINITE ELEMENT ANALYSIS OF DISSOLVED OXYGEN DRAWDOWN AND SULFATE PRODUCTION IN STRIP MINE SPOIL DAMS DUE TO PYRITIC CHEMICAL REACTION. J. H. Amend III\*, D. N. Contractor\*, and C. S. Desai\*. Dept. of Civil Engineering, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24060

The problem of dissolved oxygen drawdown and sulfate production in strip mine spoil dams is investigated. A finite element analysis is used to solve the diffusion-convection equation assuming steady state conditions and no internal oxygen sources. Oxygen recharge along the free surface is permitted. The analysis is performed in three steps. Step one calculates the nodal piezometric heads and elemental bulk fluid velocities. Steps two and three determine the nodal dissolved oxygen and sulfate concentrations. Solutions are presented for a wide range of soil permeabilities and dissolved oxygen reaction coefficients.

It is found that as the dissolved oxygen reaction coefficient decreased, the dissolved oxygen deficit decreased and the sulfate concentration increased. From these results it was found that the maximum dissolved oxygen deficit occurs at an internal point in the dam and the maximum sulfate concentration occurs on the downstream face of the dam.

The computer program used in the analysis is written in FORTRAN IV computer language and requires a minimum of programming knowledge to implement.

INTERRELATIONSHIPS OF LAND USE PLANNING TO WATER QUALITY PROBLEMS. Salvatore J. Bellomo, P.E., A.I.P.\*, and Beth French, A.I.P.\*, Planning Environment International, Div. of Alan M. Voorhees & Assoc., Inc., 7798 Old Springhouse Rd., McLean, Va. 22101

One of the conspicuous shortcomings in past water quality management efforts was the inattention to land use as a cause of and a remedy for water quality problems. Recognition that the way we guide and manage the use of land is pivotal to water quality problems has become more widespread since passage of the Federal Water Pollution Control Act Amendments in 1972.

This paper provides a technical and institutional overview of the following aspects of land use/water quality interrelationships: characterization of the land use/water quality problem; description of the effects of land use on water quality; description of the effects of water quality on land use; evaluation of alternative land use control strategies to meet water quality goals.

The information should be particularly helpful to those engineers and planners responsible for development of plans and programs to include land use planning and controls as a technique to help achieve water quality goals.

The paper concludes with an entreaty to maintain a comprehensive environmental perspective in developing and implementing areawide water quality management plans and programs.

ANALYSIS OF STREAMS IN SOUTHWEST VIRGINIA AFFECTING WASTELOAD ALLOCATION POLICIES. S. G. Breeding\*, C. W. Bryant, Jr.\*, Thompson & Litton, Inc., Wise, Va. 24293, and R. D. Sexton\*, Va. State Water Control Board, Abingdon, Va. 24210

An example of a stream assimilation analysis is presented step by step. Inputs and assumptions necessary to perform the analysis are discussed along with the problems encountered during the analysis. Solutions to these problems are offered in the conclusions of the report. Proposed solution demonstrates the necessity for treatment of pollution sources other than major point discharges.

PILOT PLANT STUDIES, ARMY MUNITION PLANT WASTEWATERS. V. J. Ciccone, US Army Mobility Equipment Research and Development Center, Fort Belvoir, Va. 22060

Wastewater discharges from Army munitions plants consist of a wide spectrum of waste streams each having its own respective characteristics. The nitro-glycerine (NG) waste stream is especially unique and challenge the present "state-of-the-art", for waste analysis and treatment. The available data on these streams are considered limited and insufficient for a confident evaluation and the development of firm pollution abatement program recommendation.

A pilot plant program has been developed to demonstrate treatability of the various waste streams and optimize wastewater treatment processes. Since treatment of munitions plant wastes has not been previously demonstrated the pilot plant is highly flexible and contains a relatively wide selection of unit processes. The product of these investigations will be the formulation of full-scale design criteria and definitive unit-process flow diagrams which can be translated with confidence to the design of prototype plants.

MODELING OF WATER QUALITY FROM A WATERSHED DISTURBED BY CONTOUR MINING. J. F. Connell, Jr., D. N. Contractor\* and V. O. Shanholtz\*, Dept. of Civil Engineering, Va. Polytechnic Inst., Blacksburg, Va. 24061

Various modeling techniques were applied to a watershed disturbed by contour mining in order to describe the functional relationships between certain water quality parameters associated with the disturbed watershed. Two approaches were considered in constructing a model. The first was to try to interrelate the flow of water with the kinetics of the chemical reactions occurring in the disturbed watershed, resulting in a dynamic model. The second was to use available measured information from an instrumented watershed and construct a static model. The latter approach was selected due to the difficulty in trying to quantify the wide variations that exist in spoil properties and reaction rate coefficients within a spoil pile. Linear and least-squared techniques were used to solve for the model weighting coefficients. Two sets of data were analyzed. The first covered a period before mining and the second set covered a period during mining. Illustrations are given of the predictive capability of the model also model errors and contributing factors are also considered.

WATER RESOURCES MANAGEMENT IN VIRGINIA: EVALUATION OF THE ADMINISTRATIVE STRUCTURE. W. E. Cox\* and W. R. Walker. Va. Water Resources Res. Ctr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Water resource management in Virginia has never been perceived as a comprehensive program from the viewpoint of administration at the State level of government. The traditional approach has been to develop special programs to manage individual problem areas as their significance has been recognized. Certain inter-agency coordination mechanisms have been developed, but the existing structure strongly reflects this problem-oriented approach.

Due to functional overlap in certain areas, there appears to be a need for further development of inter-agency coordination mechanisms. Many of the existing arrangements are somewhat informal agreements that should be strengthened through formal recognition, and additional areas exist where broader agency input should be assured. Transfer of responsibilities to different agencies may be desirable in certain cases. Any future expansion of State managerial functions must involve careful consideration of administrative compatibility in order that coordination problems not be further aggravated. (Aided by Office of Water Research & Technology, U. S. Department of Interior, Grant B-025-VA.)

REMOTE MONITORING OF WATER POLLUTION. John B. Hall, Jr.\* NASA Langley Research Center, Hampton, VA 23665

Water pollution has become a problem of increasing concern in most areas of the world. This worldwide problem occurs in bodies of water as diverse as farm ponds to the open oceans. The situation was created primarily as a result of man's rapid population growth and his rising standard of living. Water pollution, if not controlled, will threaten to destroy both our food and water supplies. In order to aid in providing a solution to this problem, it is necessary to develop monitoring technology that will rapidly detect and measure pollutants over large areas of water. Remote sensing technology is applicable to this problem.

This presentation gives a summary of the water pollution problem, describes several remote sensing concepts to monitor water pollution, and summarizes the results of several research efforts to monitor water pollution.

PRACTICAL ASPECTS OF WATER QUALITY MODELING. DAVID M. JENSEN\*, Virginia Military Institute, Lexington, VA. 24450

Key Words: Water Quality, D.O. Model, Reaeration coefficient, Stream data.

The movement and assimilation of waste materials discharged into streams and estuaries is a function of hydrodynamic transport and biological and chemical reactions. The presence of specific factors such as, aquatic biota, suspended material, plant growth and bottom sediments may influence the response of a receiving stream. These key variables may be incorporated into a mathematical model of stream response with certain waste load inputs. Digital computing techniques can be utilized to establish model solutions that reflect the various changes in the aquatic system.

This paper is concerned with the ability of a particular stream response model, based on steady-state deoxygenation-reoxygenation relationships, to predict dissolved oxygen values that would exist in streams at estimated low flow conditions.

A basic weakness of any oxygen-balance model lies with the prediction of the reaeration coefficient which is a function of stream velocity and depth. A single formula designed to predict the reaeration rate of streams at any flow rate may not be realistic.

This study concerns the use of stream surveillance data to examine reaeration predictions in the upper James River Basin. An attempt will be made to develop more precise reaeration coefficient relationships and apply these to low flow modeling of stream dissolved oxygen content.

STABILITY OF CRYSTAL PLATES. Xanthippi Markenscoff\*, Dept. of Engineering Science and Mechanics, V.P.I. & S.U., Blacksburg, Va. 24061

The stability of crystal plates is studied using the theory of small deformations superposed on finite initial deformations and two-dimensional equations are deduced in Lagrangian formulation according to Mindlin's power-series expansion. These equations are applied in the case of flexural buckling and an analytic formula is obtained showing the effects of anisotropy and material nonlinearity.

References: 1. R. C. Y. Lee, Y. S. Wang and X. Markenscoff, "High Frequency Vibrations of Crystal Plates under Initial Stresses", J. Acoust. Soc. Amer., Vol. 57, No. 1, pp. 95-105 (Jan. 1975). 2. A. E. Green, R. J. Knops and N. Laws, "Large Deformations Superposed Small Deformations and Stability of Elastic Rods", Int. J. Solids Structures, Vol. 4, pp. 555-577 (1968).

A NUMERICAL SOLUTION FOR A TURBULENT, THREE-DIMENSIONAL, HEATED, RECTANGULAR JET INTO A SHALLOW, OPEN CHANNEL. D. M. Markham and C. H. Lewis. Aerospace and Ocean Engrg. Dept., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

A numerical model for a turbulent, three-dimensional, heated, rectangular jet into a shallow, open channel is presented. The steady-state Navier-Stokes equations are solved numerically using a vorticity-velocity formulation in order to predict the spreading of the jet and the temperature distribution in the jet mixing region. A variable eddy viscosity is used with the retention of the more significant gradient contributions of it in the governing equations. A Boussinesq approximation of the body force is used. The results obtained for laminar flow in a square duct and for an unheated turbulent jet are presented as a test of the model. The term involving the gradient of the eddy viscosity in the equation for the vertical component of the vorticity is shown to significantly increase the spread of the jet. The results for the turbulent, three-dimensional, heated, rectangular jet in a shallow, open channel give a reasonable prediction for the jet spread in the near jet region, but a large underprediction for the far field region. The temperatures in the jet mixing region are higher than those obtained experimentally. The results also show qualitative aspects, such as the jet's vortex, spread, rise and its entrainment of freestream fluid. (This work was supported by funds provided by the U. S. Dept. of Interior, OMWR, as administered by the Virginia Water Resources Center as Project B-041-VA.)

AN ANALYSIS OF CURRENTS AND CIRCULATION IN HAMPTON ROADS. Bruce J. Neilson. Dept. of Physical Oceanography & Hydraulics, Va. Inst. of Marine Science, Gloucester Pt., Va. 23062

Current measurements made by the Coast & Geodetic Survey in 1951, 1962 and 1969 and by VIMS in 1969 and 1971 were analyzed to determine the circulation patterns in the Hampton Roads area. A "right hand dominance" of flows was observed. During flood tides the flow was greater on the northern side of the channel and turned sharply around Newport News Point. During ebb tide the flow turned gradually, with the greater portion passing through the natural channel to the south of Newport News Middle Ground. The circulation in this region is influenced greatly by differences in tidal phase. In general, the tide wave passes through Hampton Roads and up the James River as a progressive wave, whereas slack tide occurs almost simultaneously throughout the Elizabeth River system like a standing wave. Strangely enough, the tide wave appears to move down the Nansemond River. The ebb flows from the James and the Nansemond are directed towards the naval piers south of Sewell's Point, causing the flow from the Elizabeth to hug the shoreline. At late ebb these flows also enter the Elizabeth River since the tide turns earlier there.

AN ENGINEERING SOLUTION TO IMPROVE WATER QUALITY IN A TIDAL LAGOON. R. W. Price\*, and C. Y. Kuo. Dept. of Civil Engr., Old Dominion Univ., Norfolk, Va. 23508.

Rising demand for better water quality has stimulated research and development of ways to improve the quality level in existing as well as proposed water systems. At present, most of the solutions focus on biological and chemical processes.

Many natural or man-made water bodies act as receivers for both point and non-point pollution sources. Employment of biological and chemical treatment has proved successful in many of these cases; however, in some cases a more natural physical solution of an engineering mode would be more desirable. A "flushing" technique using the tidal fluctuation as a driving force has been investigated and the water quality level monitored as a function of several dimensionless variables. Two types of outlets for flushing were considered - first, an open-channel system and second, a culvert system. With the aid of modeling techniques, detailed information has been generated to be applied in water quality analysis and engineering design.

NONLINEAR STREAMING IN BOUNDARY LAYER FLOW. M. Romanuk, and D. P. Telonis. Dept. of Eng. Science and Mech., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The response of the laminar boundary layer to oscillations of the outer stream has been studied up to now either via asymptotic expansions<sup>1</sup> or through numerical calculations<sup>2</sup>. All such asymptotic expansions in literature were confined to large or small values of the frequency,  $\omega$ , and were truncated at the linear term of the outer flow oscillation expansion  $U(x, y, t) = U_0(x, y) + \epsilon U_1(x, y) e^{i\omega t} + \epsilon^2 U_2(x, y) e^{2i\omega t} + \dots$ .

It is presently proposed to use the expansion only in powers of  $\epsilon$ . In this way the number of independent variables is reduced from three to two. Partial differential equations are then solved numerically with the frequency,  $\omega$ , as a parameter and the reduction in computer time and space is drastic. The method is not confined to sinusoidal oscillations of the outer flow or to specific body configurations that permit similar solutions of the steady part of the flow. Collecting terms of order  $\epsilon^2$  the perturbation gives rise to terms independent of time, that correspond to the steady streaming phenomenon<sup>3</sup>. Preliminary numerical calculations have been performed to compare the phase differences and velocity overshoots with previous analytical or experimental methods. References: 1. Ackerberg, R.C. and Phillips, J.H., J. Fluid Mech., 51, 137-157 (1972). 2. Tsalahis, D.Th. and Telonis, D.P., AIAA J., 12, 1469-1476 (1974). 3. Stuart, J.T., J. Fluid Mech., 24, 673-687 (1966).

PREDICTION OF ALGAL GROWTH POTENTIAL FROM CHEMICAL NUTRIENT ANALYSIS. M. D. Smolen\*, Southern Piedmont Res. and Cont. Educ. Ctr., Blackstone, Va. 23824

Weekly water samples were obtained from the reservoir and major tributary streams of the Occoquan watershed and analyzed for forms of nitrogen and phosphorus. A portion of these samples were also subjected to ACP analysis using *Anabaena* and *Selenastrum*. Distinctly different responses were noted for the two test species on water samples from several locations. Correlation analysis for ACP yield with chemical nutrient parameters indicates that nitrate and phosphate concentrations relate closely to the ACP yields observed. Although ammonium ion concentration was observed to vary from extreme low to extreme high levels, no significant positive correlation with ACP yield was noted.

A series of curves is presented which show observed ACP yield as a function of nitrate concentration at various phosphate levels. The results indicate that nitrate concentration determines *Selenastrum* yield when phosphate concentration is greater than .010 mg-P/L. *Anabaena*, however, responds to nitrate concentration only when total phosphate concentration is greater than .150 mg-P/L.

MECHANICAL PERFORMANCE OF POLYGLYCOLIC ACID SUTURES. Jill Stein\*, John Thacker\*, M.S.M.E., George Redeveaver\*, Ph.D., J.W. Moore\*, Ph.D., Richard F. Edlich\*, M.D. Dept. of Plastic Surgery, Dept. of Mech. Engr., Univ. of Va., Charlottesville, Va. 22901

A study of the properties of two new polyglycolic acid (PGA) absorbable synthetic sutures was made to determine mechanical reliability of these sutures on a comparative basis. Tensile strength, knot holding force, and knot slippage were examined using knots tied at standardized tying tensions. The square, surgeon, and granny knots were tied and tested using two to five throws. The sutures were tested dry and were then soaked in plasma to stimulate "in vivo" performance. These knots were tested on an Instron Tensile Tester with the patient's side of the knot inserted into the jaws and extended at a constant rate.

Comparison of the properties of the two PGA sutures with those of a silk suture showed that the slippage was less for the PGA and knot holding force slightly greater. The PGA knots secured with two throws in all cases but one, requiring less throws than silk and therefore leaving less foreign material in the wound. Surgeons should be aware of the advantages of the PGA sutures and its performance.

INSTREAM BIOMONITORING OF INDUSTRIAL WASTEWATER EFFLUENTS. Garson F. Westlake. Biology Dept., VPI&SU, Blacksburg, Va. 24061

The present level of surveillance of industrial waste discharges is too irregular to detect many damaging spills from point sources. Even when a spill is detected, it is often too late to take any meaningful corrective action. Chemical-physical monitoring frequently does not enable one to predict the toxicity of complex waste effluents. However, a biological monitoring system is able to integrate these effects and provide an early warning of changes in toxicity. A fully automated biological monitoring system using sublethal responses of fish has been developed and tested successfully in the laboratory since 1967. A description is given of its installation on an industrial site. The monitoring is carried out remotely over standard telephone lines and evaluations are made by a small computer on a continuous basis automatically producing alarms of developing toxic conditions at the site where they are produced.

## Abstracts of Papers

# Section of Environmental Science

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

**CHRONIC IMPACTS OF OIL IN THE MARINE ENVIRONMENT.** Roger D. Anderson. Va. Inst. of Mar. Sci. Gloucester Pt., Va. 23062

An overview of fate and effects of petroleum hydrocarbons in the marine environment is presented. Assessment of existing published and unpublished information is made, particularly in relationship to nearshore and outer continental shelf development. Ongoing and planned laboratory and field efforts to assess acute and sublethal effects of oil on marine organisms are reviewed. New research designs, methodologies and analytical capabilities relating to chronic impacts of oil are discussed. Needs for future petroleum-related research are noted. (Support provided by API agreement no. 0520-P and Sea Grant (NOAA) grant no. 04-3-158-18 and 04-5-158-49.)

**HYDRAULIC MODEL OF LAFAYETTE RIVER FOR WATER QUALITY STUDIES.** C. Blair\* and C. Y. Kuo, Sch. of Engineering, Old Dominion Univ., Norfolk, Va. 23508.

A hydraulic model faithfully reproduces prototype phenomena if each term in the dimensionless model equations is identical in magnitude with the corresponding term in the prototype equation. Identity is obtained by choice of scales for model-to-prototype horizontal distance ( $X_p$ ), vertical distance ( $Y_p$ ), and time ( $t_p$ ). The first two are set by the sizes of estuary and model laboratory. Time scale is set by the requirement for identical equations of momentum and water mass. To model transport of solute requires identical model and prototype equations for solute mass conservation. Opinion differs as to whether in a distorted ( $X_p \neq Y_p$ ) model, the solute conservation equations can also be identical. We are testing the hypothesis that they can be identical and hence that solute transport can be successfully modeled - as one must in water quality studies.

We have built a 30'x50'24" model of the Lafayette River based on prototype field data. Dye diffusion tests in model and in prototype will be compared to find out if similitude is attainable.

**THE DECLINE OF DDT.** R. B. Brandt, Dept. of Biochemistry, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298

DDT (dichloro-diphenyl-trichloro ethane) was first synthesized in 1874 by O. Zeidler. In 1939 it was found to be highly effective in killing potato bugs. By 1942, it was known to kill many other insects including the disease vectors, mosquitoes, flies and fleas. It was rapidly and effectively used in WWII and was credited with saving millions of lives in prevention of typhus and malaria. In 1948 Miller was awarded the Nobel prize for its use.

DDT was too good! It was inexpensive to manufacture and use as well as without apparent human toxicity. It was used with little regard for its concentration in the ecological scheme (including man). Its solubility in fatty tissues led to the eventual awareness that it could disturb various ecosystems. Suggestions were made in 1930 that decline in the bird population were caused by DDT. Strong correlation have been made between egg shell thinning and DDT use, however, the sublethal effects on other species are unknown. A decline in usage for many reasons was enforced by a ban in the U.S. in December of 1972 on all but selective, defined application. The dramatic effects of these selective applications as well as its effective use against malaria carrying mosquitoes still are strong arguments for use. Recently, Johnston (Science 186, 841 (1974) has shown a decline in DDT in fatty tissue of migratory songbirds that correlates with decreased use of DDT. This finding is also consistent with decline in water and water species.

**THE DECLINE OF A RESERVOIR: THE STUDY OF SEDIMENTATION POLLUTION IN THE OCOQUAN RESERVOIR.** Edwin Brown III, Dept. of Biology and Geology, Mary Washington College, Fredericksburg, Va. 22401

Sedimentation pollution is a big problem in the Ocoquan Reservoir. The study is performed by the collection of chemical soil and water data. The values of the Ocoquan Reservoir are compared with those of the Breckinridge Reservoir (a reservoir that is not subject to high run off) which functioned as a control. The amount of soil transport is indicated by the comparison of values at the uneroded, eroded, and deposition sites of the study area.

The study indicates that huge amounts of sedimentation have occurred which manifests itself as increased values of  $\text{HCO}_3$ ,  $\text{Ca}$ ,  $\text{Mg}$ ,  $\text{Fe}$ , and  $\text{CO}_2$ . The chemical data is complicated by the presence of huge populations of such pollution indicator species as blue-green algae, iron and sulfur bacteria, and Tubifex worms. Physical data indicates an overall decrease in the reservoir depth, formation of sandbars in the reservoir, formation of mudflats in the reservoir's tributaries.

The huge amounts of sediment has increased the productivity of the reservoir manifold. This has resulted in an unstable ecological situation because of the huge amounts of nutrients being introduced via sedimentation. There has been a corresponding increase in BOD which has resulted in the reservoir progressing to an advanced eutrophic state.

ATMOSPHERIC AND MARINE FLOW PROBLEMS INTRODUCED BY OFF-SHORE FACILITIES AND ICEPACKS. Kuldip P. Chopra, *Old Dominion University, Norfolk, Virginia 23508.*

Atmospheric and oceanic flow problems introduced by islands considered in an earlier paper<sup>1</sup> are applied to icepacks and off-shore facilities like airports, nuclear plants, oil-storage or tanker-anchorage facilities, deep water ports, and artificial islands for residential, industrial, recreational or waste disposal purposes. The paper deals with only fluid-dynamical environmental problems. Whereas the horizontal thermal differences would produce atmospheric effects similar to those related to natural and urban-heat islands, increase in surface water salinity due to contact with floating icepacks or due to increased evaporation caused by thermal pollution of off-shore facilities is likely to produce vertical circulations which may cause dislocation of fish schools. The discussion will include the effects these facilities may have on regional climate and environmental quality.

<sup>1</sup>Atmospheric and Oceanic Flow Problems Introduced by Islands. *Advances in Geophysics* 16, 297 - 421 (1973).

Pb, Zn, and Mn IN DREDGE SPOIL POND ECOSYSTEMS. J. E. DRIMETER and W. S. ODUM. Dept. Environmental Sciences, Univ. of Virginia, Charlottesville, Va. 22903

Pb, Zn, and Mn levels in sediment and common estuarine plants and animals colonizing dredge-spill disposal areas were compared with levels occurring in the same materials from a natural salt-marsh.

Pb levels in the Grass Shrimp (*Palaemonetes pugio*), Mummichog (*Fundulus heteroclitus*), Common Reed (*Phragmites communis*), Saltmarsh Cordgrass (*Spartina alterniflora*) and Saltmeadow Hay (*Spartina patens*), from dredge-spill areas, were significantly higher at the 0.01 confidence level than in these species from the natural salt-marsh. Zn concentrations were significantly higher at this confidence level in the three plant species growing in dredge-spill compared with those from the natural marsh. Mn content in Grass Shrimp from ponds in dredge-spill disposal areas was significantly higher (0.05 confidence level) than in those from the natural marsh. Thus, dredge-spill containing heavy metals, even though disposed of in specially designed diked containment areas, may act as a source of certain heavy metals that are potentially toxic to the biota.

Data on the transfer of Pb and Mn in simple food-chains of the dredge-spill pond ecosystem are presented and discussed in relation to feeding behavior. Decreasing concentrations with increasing trophic level were observed for Pb and Mn, but no consistent pattern was noted with Zn.

INVESTIGATIONS OF REMOTE SENSING TECHNIQUES FOR EARLY DETECTION OF DUTCH ELM DISEASE. R. S. Hammerslag, National Park Service, Washington, DC, and W. J. Sopotylo, NASA Wallops Flight Center, Wallops Island, VA 23537

Several forms of aerial photography were pursued in quest of a technique which could provide early detection of Dutch elm disease. The two most promising techniques tested were multispectral photography with object enhancement and band ratioing coupled with scanning microdensitometry. For practical purposes the multispectral system has the advantage of providing a readily interpretable image in a relatively short time. Laboratory studies indicated that less emphasis should be placed on the use of a red filter or the near infrared beyond 750 nm for early detection of stress within a single plant species. Color infrared film would be optimal when used for a long term detection of loss of plant vigor which results in a physical change in a plant canopy, but should find minimal practicality for early detection of specific sources of plant stress such as Dutch elm disease. Considerable discretion should be used when interpreting imagery on copy film because of loss of resolution and color definition.

HYDROFOILS FOR CONTROL OF OUTFALL EFFLUENTS IN RIVERS. R. C. Costen\*. Space Applications and Technology Division, NASA-Langley Research Center, Hampton, VA 23665.

The objective of this theoretical research is to show that the dispersion of outfall effluents in rivers can be either increased or decreased through the use of hydrofoils located near the outfalls and elsewhere in the flow. Analytic studies indicate that a short semispan hydrofoil mounted vertically upward from a river bed generates a long vortex wake that is deflected laterally with respect to the free stream. The deflection angle is independent of the flow speed and can be varied between limits of about  $\pm 4^\circ$  by adjusting the lift coefficient and other parameters of the hydrofoil. The deflected wake contains a semicylindrical region of recirculating water that does not mix with the rest of the river flow. Locating the hydrofoil near an outfall could cause the effluent to be entrained in the recirculating part of the wake. Thus dispersion of the effluent could be reduced until at some point downstream the wake breaks up; moreover, the wake could be extended indefinitely by placing additional hydrofoils at downstream locations to regenerate the wake. Such a wake would form an extended "pipeline" for the concentrated effluent, with the rest of the river being relatively unpolluted. Alternatively, dispersion of the effluent through the river flow could, if desirable, be accelerated, since the deflection angle of the wake is controlled by the set of the hydrofoil. By periodically reversing the angle of attack, the wake could be made to sweep back and forth from one bank of the river to the other.

THE EFFECT OF THE SPRING-NEAP TIDAL CYCLE ON THE VERTICAL SALINITY STRUCTURE OF THE JAMES, YORK AND RAPPAHANNOCK RIVERS. L. W. Hagg, Va. Institute of Marine Science, Gloucester Point, Va. 23062

Hydrographic data from the lower York and Rappahannock Rivers for 1974 revealed that both of these estuaries, previously considered to be moderately stratified, oscillated between conditions of vertical stratification and homogeneity on a cycle that was closely correlated with the spring-neap tidal cycle, i.e. mixing was most highly developed 3-5 days following maximum monthly spring tides while stratification was most highly developed 3-5 days following minimum monthly neap tides. For the lower York, the cycle was best described by the equation  $\log \Delta\sigma/\sigma = -3.20 \sin(\omega t + 4.32)$  (eq. 1),  $\omega = .667$ ,  $\Delta\sigma/\sigma$  where  $\Delta\sigma/\sigma$  is the surface-to-bottom salinity difference and  $\text{PHTML}_4$  is the mean daily predicted high tide height (in meters) four days prior to the salinity observation.

Analysis of hydrographic data from the post-Agnes period (July-August 1972) revealed cycles of stratification and mixing occurring simultaneously throughout the salt influenced lengths of the James, York and Rappahannock Rivers that were similar to the cycle described above. I interpret these cycles to be a manifestation of the normal oscillatory nature of the estuaries and not a result of Hurricane Agnes.

The ramifications of a regular cycle of stratification and mixing on estuarine classification, modeling, management, sampling and biological processes must be considered.

HYDROCARBON POLLUTANTS IN FISH. T. B. Hill\*, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

Column and gas chromatographic procedures which were used to determine polynuclear aromatic hydrocarbons (PNAHs) in fish, may be applicable as a screening method for analysis of fish suffering from modest levels of hydrocarbon pollution.

Ground fish were blended with anhydrous magnesium sulfate for Soxhlet extraction with refluxing benzene. After saponification of the extract with methanolic potassium hydroxide, the aliphatic hydrocarbons were separated by cyclohexane elution from a basic alumina column. The PNAHs were separated by benzene-ether elution. Analysis of the latter eluate by flame ionization gas chromatography showed that PNAHs, from deliberately contaminated blended fish samples, would be easily detected at levels of one part per million based on fish weight.

Infrared spectra and gas chromatograms of above-processed fish, taken from areas suspect of hydrocarbon pollution, will be shown.

**ESTIMATION OF POLLUTION MODEL PARAMETERS USING REMOTELY SENSED DATA.** James F. Kibler\*, Space Applications and Technology Division, NASA-Langley Research Center, Hampton, VA 23665.

The purpose of this study is to simulate the process of statistically estimating the parameters of a water pollution transport model from remotely sensed data. A two-dimensional version of Akira Okubo's instantaneous-release advection-diffusion model is used as a representative water pollution transport model. This model requires five unknown parameters to yield an evaluation of pollution concentration for given spatial coordinates and time. A remote sensor is modeled as an  $n \times n$  array of elements which sense upwelled radiance at known spatial coordinate. The sensor model introduces three additional model parameters. Sample data is simulated by adding Gaussian noise to the modeled concentration for a given set of model parameters. Then, a weighted least squares batch processor is used to estimate the model parameters from data. A parametric study investigates the performance of the estimation process for such variables as (1) noise in the data, (2) the number and spacing of images from the sensor, (3) the number of pixels in each image, and (4) sensor resolution. The results of this simulation should directly affect the design of future pollution monitoring instruments and the way that those instruments are used.

**OVERWASH SEDIMENTATION ON ASSATEGUE ISLAND.** Stephen P. Leatherman\*, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903

Assateague Island, a 33 mile barrier along the Atlantic Coast of northern Virginia and southern Maryland, is highly vulnerable to hurricanes and northeasters due to its exposed position and low physiography. Overwash, i.e., the transport of sea water and associated sediment across the island during storms, is a major component of the barrier islands response to these high energy conditions. Although several dune building programs have been undertaken, numerous wash-over sites are active, particularly on the northern end of the island. These sites overwash several times each year and serve as an excellent laboratory for a detailed study of the overwash process.

Primary interest is placed on the quantification of sediment transport across the dune line onto the barrier flats in a single overwash event. Comparison of before and after profiles, obtained by standard surveying procedures, allows for a volume calculation. Additionally, emphasis is placed on relating the hydraulics, i.e., surge velocity and flow depth, of the overwash event to the resulting sedimentary deposit. This technique of investigation yields a new insight into the hydrodynamical interpretation of storm-generated sedimentary sequences and bedding structures.

**RESULTS OF THE SKYLAB ALTIMETRY EXPERIMENT FOR MAPPING SEA SURFACE FEATURES.** J. T. McGoggan\*, NASA Wallops Flight Center, Wallops Island, VA 23337

A description of typical satellite altimeter concepts and instrumentation is presented. The parameters measured, geometry utilized, supporting data, and techniques employed will be discussed. Based on the analysis of the SKYLAB S-193 altimeter experiment, results will be shown which illustrate the programmatic altimeter technology gained and demonstrate the scientific potential of altimetry for various applications.

It will be shown that there exists a very strong correlation between subsurface topography in the broad ocean area and the shape of the ocean surface as determined from the altimeter. Results over escarpments, trenches and sea mounts will be presented. The agreement of existing geoid models with the altimeter data will be shown. In addition the application of this topographic data for detection of currents and geological structure will be discussed. Future programs and their corresponding altimeter instrumentation will be outlined.

**AN AIRBORNE LASER BATHYMETRIC SYSTEM.** H. H. Kim\*, NASA Wallops Flight Center, Wallops Island, VA 23337

In recent years, the use of a fast pulse laser for shallow coastal water depth survey has been proposed by others. NASA Wallops Flight Center, under the auspices of NASA and U.S. Naval Oceanographic Office, has developed an airborne laser bathymetric system. The system was successfully flight tested on NASA research aircraft during August 1974 and February 1975 over the test areas of Naval Key West Air Station, Boca Chica, Florida.

The missions were to determine the intensity of laser beam reflected from the ocean bottom and to characterize the influences of various ocean parameters on the beam. The sea-truth support of a surface vessel was deployed often at the time of the overflight. Two different transmitters (pulsed neon ion laser and Nd-YAG laser) were used in the studies of the platform altitudes, beam polarization and spatial and spectral filtering technique.

From the tests, the team was not only able to produce the first underwater topographic profile which was generated by the laser technique but also to increase the platform altitude to 600 meters so that the technique could be integrated with an airborne aerial survey camera system. The photo-laser integration system will consist of an aerial camera, precise navigation positioning system, and a laser bathymeter. It will provide aerial stereo images that are correlated with horizontal positions and water depths for hydrographic charting.

**RESEARCH OPPORTUNITIES IN THE GREAT DISMAL SWAMP.** G. F. Levy, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Through the years numerous of articles have been published on various aspects of the Great Dismal Swamp. Relatively few of these publications are substantive and many are dated. The recent designation of over 49,000 acres of this region as the Dismal Swamp National Wildlife Refuge has served to renew researchers' interests in this remarkable area. For almost ten years biologists at Old Dominion University has been conducting a wide range of investigations in the swamp. Lately they have been joined in their efforts by other Old Dominion University Scientists as well as by investigators from other Virginia schools including Virginia Polytechnic Institute and State University, Virginia Wesleyan College, College of William and Mary, and Longwood College. Permission to conduct research must be secured from the Dismal Swamp Refuge Staff in Suffolk. Old Dominion University's Dismal Swamp Center for Education and Research is interested in assisting qualified individuals interested in Dismal Swamp research. Inquiries should be directed to the author.

**WATER QUALITY STUDIES IN THE ELIZABETH RIVER.** Bruce J. Neilson & Albert Y. Kuo\*, Dept. of Physical Oceanography & Hydraulics, Va. Inst. of Marine Science, Gloucester Pt., Va. 23062

Despite the importance of the Elizabeth River for commerce, naval facilities, recreation and other uses, very little information on water quality and hydrography can be found in the published literature. A series of dye studies and hydrographic surveys were conducted in the years 1972-74 to provide a better understanding of the dynamics of the system and to document existing water quality conditions.

The studies showed that water quality violations occur throughout the system and for several months each year. The large volume of treated sewage and industrial waste products discharged to the river reside in the system for extended periods. Reseration is low in some reaches due to mean depths on the order of 10 meters. Tidal mixing appears to be the dominant physical transport process within the system; "flashy" runoff from the drainage basin and stratification conditions in Hampton Roads are also important controls during some periods of the year.

SUMMERTIME PRECIPITATION PATTERNS OBSERVED BY RADAR OVER THE MID-ATLANTIC COASTAL REGION. J. Parsons, E. Astling, and J. White, Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

Precipitation echoes observed by the Patuxent and Cape Hatteras WSR-57 radars were digitized for four hour intervals during the month of August from 1971 to 1973. Analysis of diurnal variations of echo occurrence shows a pronounced nocturnal maximum over the Gulf Stream in the Atlantic Ocean and a weaker afternoon maximum over inland areas. Echoes occurred less frequently over the Chesapeake Bay than adjacent land areas at all hours of the day. The results indicate low level convergence on a synoptic scale combined with a land breeze circulation to produce the offshore nocturnal precipitation.

EFFECTS OF AIR POLLUTANTS ON METEOROLOGICAL PARAMETERS AT NORFOLK, VIRGINIA. W. Maurice Pritchard, Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508

The results of a continuing study of the influence of particulate air pollutants on meteorological parameters at Norfolk, Virginia are presented. Statistical analyses of historical data on precipitation and visibility are given. For the 15 year period 1960-1974, the data indicate an increase in the frequency of low visibility days and an increase in the annual number of days with precipitation greater than or equal to 0.01 inch. Both of these effects may be due to particulate air pollutants. The significance of the correlation between the time series data for frequency of low visibility and frequency of days with low precipitation ( $\leq 0.01$  inch) is examined.

SUNSPOTS, MOON PHASES, AND WEATHER PREDICTION Boyd E. Quate  
Boyd E. Quate & Associates, Holland, Virginia 23437.

An objective technique has been developed whereby Zurich sunspot numbers are utilized in selecting historical weather patterns (analogues) that can be used to prepare long range weather forecasts. In this technique timing is based upon lunar weeks and months, with the first day of each lunar month being the date of the New Moon. The Zurich sunspot numbers have been plotted for each day of the lunar weeks and months for the past 75 years. Weather analogues are selected from those historical periods when the sunspot curves are similar to the current data. A 3-lunar month time lag between the weather patterns over the USA and the Zurich sunspot numbers has been detected. It is this time lag that allows the sunspot numbers to be useful in the preparation of long range weather predictions.

Forecasts based upon analogues with non-similar sunspot curves produced forecasts with an accuracy of only 46%, whereas forecasts based upon analogues with similar sunspot curves produced forecasts with an accuracy of 78%.

The Problem of Airsheds, Wallace E. Reed, Gregory S. Hogue. Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903.

Planners propose establishing airsheds to generate clean air upwind which would increase dilution in highly polluted areas. Zoning or other measures would protect these airsheds. It can be demonstrated that meteorological processes and biological productivity seldom interact in the fashion anticipated by the planners. The dilution benefits of an airshed would be minimal or nonexistent. However, it appears the air filtering effect of vegetation in airsheds may have considerable beneficial effects worth further investigation. Until these effects are fully documented, special zoning or other controls for airsheds do not seem appropriate.

BEHAVIORAL RESPONSE OF MOSQUITO LARVAE USED IN ASSESSING HEAVY METAL POLLUTION. D. E. Simonet\* and R. C. Turner, Jr. Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Negative phototactic behavior exhibited by larval *Aedes aegypti* (L.) (Diptera: Culicidae) was used as a parameter in the assessment of toxic levels of heavy metals in water. First instar larvae were exposed to a toxic solution for eight hours before testing and those unable to migrate 30 cm. within one minute were recorded.  $EC_{50}$  values were determined for copper (1.3 ppm), cadmium (.6 ppm), and chromium (8.9 ppm). Field collected samples of effluents were also collected and tested. Analysis of results indicated that this test could be implemented as a rapid monitor for heavy metal toxicity in effluents.

CAN MAN CONTROL THE WEATHER? J. Simpson, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903

Weather modification is a controversial interface between science and society. Part of the controversy concerns feasibility demonstration; part is socio-political. Feasibility demonstration is difficult because of enormous natural variability, small experimental samples, and imperfect understanding of the basic fluid processes involved. The science of intentional weather modification is young, beginning with Schaefer's discovery of supercooled cloud seeding in 1947. Conclusively proven modification results have been modest but real. Only about a half dozen properly conducted weather modification experiments have achieved results accepted by the majority of the scientific community. Success is defined as a statistically significant and physically sound cause-effect demonstration between the treatment and effect. The so-defined successful experiments involve cold fog dispersion and precipitation augmentation, the latter mainly from winter storms and orographic cloud systems. An outstanding result is that treatment effects depend on the initial conditions of the systems, so that the same treatment may produce opposite results in different situations. Promising efforts are underway in hail suppression, lightning suppression and tropical hurricane mitigation.

Cumulus clouds are the building blocks of many beneficial rain systems and all severe storms. A 12-year program to understand and usefully modify cumulus clouds systems is described.



PREFERENTIAL CONCENTRATION OF TOXIC ELEMENTS IN SMALLER AEROSOLS. J. J. Singh, D. C. Woods\*, NASA Langley Res. Ctr., Hampton, Va. 23665, R. K. Jolly\*, S. K. Gupta\*, G. Randers-Pehrson\*, D. C. Buckle\*, and H. Aceto, Jr.\*, Va. Assoc. Res. Ctr., Col. of William and Mary, Newport News, Va. 23606

Aerosols from aircraft engines were collected for 24 hours with an Andersen eight-stage cascade sampler. The aerosol samples from each stage were analyzed for their elemental composition using the proton induced X-ray emission technique. Seventeen elements (Si, P, S, Cl, K, Ca, Ti, V, Fe, Ni, Cu, Zn, Br, Sr, Nb, Sn, and Pb) were identified and quantitated at each stage. Six elements (S, Ca, Fe, Zn, Sr, and Pb) showed fractional concentration increase with the decreasing aerosol size. Similar, but less well defined, trends were also observed for V and Ni. Silicon and chlorine, on the other hand, showed an opposite trend. Fractional concentrations for the other elements were essentially constant among the various stages.

A METHOD FOR THE MEASUREMENT AND THE STATISTICAL ANALYSIS OF ATMOSPHERIC TURBULENCE. H. W. Tieleman. Dept. of Engineering Science and Mechanics, VPI & SU, Blacksburg, Va. 24061

Instantaneous voltage measurements representing the wind velocity and the temperature are obtained with a three dimensional anemometer system. The output voltages are sampled at a rate of 200 samples per second, digitized and stored on digital magnetic tape. These data are gathered by a specially designed data acquisition system. New calibration procedures permit rapid conversion of the digital voltages into velocity components and temperature. Each 40 minute data sample is divided into 58 blocks consisting of 8192 data points each. Stationarity of the time histories is checked by inspection of the block-means and block-variances and is also checked with the use of a statistical trend test. The velocity components are transformed into the meanwind oriented coordinate system. Mean values, variances and covariances of these new components are calculated for each data-block and consequently averaged to produce the sample-means, variances and covariances. Power, co- and quad spectra of the wind components and the temperature are obtained with the use of a newly developed algorithm for the fast Fourier transform. Comparison of the results of this system with the results from Gill-propeller anemometers is very good. Accurate wind measurements can be made in a frequency range from 0.005 to 100 Hertz. At the present, six probes have been mounted on the 250 foot Meteorological Tower at NASA-Wallops Flight Center.

RADAR MEASUREMENT OF SIGNIFICANT WAVE HEIGHT. E. J. Walsh\*, NASA Wallops Flight Center, Wallops Island, VA 23337

The average range distribution of the return for a nadir-directed radar is just the convolution of the sea surface height distribution and the antenna pattern range weighting when only small off-nadir angles are involved. The significant wave height (SWH) can be determined using either a pulse-limited radar altimeter or a beam-limited target-referenced radar.

In the measurement of SWH using the radar altimeter it is desirable to have a wide antenna beamwidth so that the leading edge of the return will be an error function centered at ms1. The range distribution of the radar return is measured in detail and the surface height distribution is found by differentiating the leading edge of the return.

On the other hand, the beam-limited target-referenced systems have no range information, nor do they need any. They simply develop a measure of the range extent of the target and the individual measurements may be averaged directly, without alignment, eliminating the need for a range tracker. For this system, it is desirable to have a narrow beamwidth so that the system essentially observes the range extent of the surface height distribution. The advantages/disadvantages of the two types of system are discussed and some pulse-limited data are shown for various values of SWH.

BEACH PROCESSES IN A MICRO TIDAL ENVIRONMENT. A. T. Williams\*, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903

Several Hong Kong beaches were selected for a study of erosional and depositional processes. Measurements of beach elevation changes over a half-tidal cycle revealed that patterns of erosion, deposition and erosion were characteristic of an ebb tide; vice versa for a flood tide. These changes (maximum  $\pm 50$  cm) were minor in comparison with seasonal changes. The latter were brought about by shifts in the climatic pattern, producing two distinct sets of prevailing winds for summer and winter. This generally resulted in 'cut' processes in summer, 'fill' processes in winter. Statistical analysis of sediment parameters showed strongly delineated foreshore zones.

The 'step' zone was found not to be exclusively controlled by breakers. Depth of disturbance studies revealed patterns of sedimentation units, and values recorded were much greater than reported elsewhere. Breaker height and beach slope were the independent variables determining the depth of disturbance. Mean grain size was the principle control over sorting rather than the hydraulic factors.

## Abstracts of Papers Section of Geology

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

MULTIPLE DEFORMATION AND METAMORPHISM FROM STRUCTURAL ANALYSIS IN THE EASTERN PENNSYLVANIA PIEDMONT. R.V. Ament, Dept. of Geology, Madison Col., Harrisonburg, Va. 22801.

The Wissahickon Formation in the Piedmont near Philadelphia exhibits 5 generations of minor structures and 2 episodes of metamorphism,  $M_1$  and  $M_2$ . Deformation  $D_1$  produced the dominant southeastward overturned folds and was associated with basement uplift along vertical faults with diapiric rise of ultramafic rocks. Apparently the grade of metamorphism during  $D_2$  was low, but  $M_1$  predated and  $M_2$  postdated  $D_2$ .  $M_1$  was contemporaneous with  $D_1$  which produced similar folds,  $F_1$ , with axial plane schistosity,  $S_1$ , and hornblende lineation,  $L_1$ .  $M_2$  was partially contemporaneous with  $D_3$  which produced recumbent parallel folds,  $F_3$ , with horizontal fracture and crenulation cleavages,  $S_3$ .  $M_2$  outlasted  $D_3$  as evidenced by growth of porphyroblasts over  $S_3$ .  $D_4$  occurred during waning of  $M_2$  and produced a southeast dipping crenulation cleavage,  $S_4$ , which is parallel to axial planes of locally occurring folds.  $D_4$  structures become more intensely developed northwest and are possible the dominant minor structures near the Martine line.  $D_5$  structures are weakly developed.

It is suggested that (1)  $D_1$ - $M_1$  was an early phase of the Taconic orogeny, (2)  $D_2$  was a post-metamorphic phase of the Taconic orogeny associated with (pre-Silurian?) emplacement of ultramafic rocks, (3)  $D_3$ - $M_2$  was a phase of the Acadian orogeny and, (4)  $D_4$  and  $D_5$  were late phases of the Acadian orogeny or phases of the Alleghanian orogeny.

### COASTAL PLAIN GEOLOGY OF GREATER RICHMOND.

Paul A. Daniels, II. Va. Div. of Mineral Resources, P. O. Box 3667, Charlottesville, Va. 22903

Surface, subsurface, and environmental geologic maps have been constructed for four 7.5-minute quadrangles in the Richmond, Va. area. The surficial geology in these quadrangles is dominated by four genetically defined Coastal Plain sedimentary units that represent various depositional systems.

Because the physical character of the sediments can be related to the depositional environment, geologic maps of genetically defined units can aid in resolving landuse conflicts by delineating (1) geologic constraint on landuse capability, (2) areas of potential conflict, and providing (3) inventories of mineral resource potential, and (4) a natural, non-political basis for landuse planning policies.

GEOLOGY OF THE NOAK-HERSHBERGER HILLS AREA, PAGE CO., VA. C. H. Cherrywell, Dept. of Geology, Madison Col., Harrisonburg, Va. 22801.

The Noak-Hershberger Hills area, in the upper central 1/4 of the Big Meadows 7.5-minute quadrangle, is on the western flank of the Catoclin Mountain-Blue Ridge anticlinorium.

Pedlar Fm. and the Catoclin Fm. (expanded to incorporate the former Swift Run Fm. as the basal unit and the Loudoun Fm. as an upper metasedimentary unit) underlie the lower Cambrian Chilhowee Group (Weverton, Harpers, Antietam Fms.) with overturned dips of 30-80 SE, striking N30-40 E. Stratigraphic thickness of the Weverton was decreased to 600' and the Harpers increased to 2600' based upon only the former containing quartz pebbles in its phyllite and ferruginous sandstone beds.

Detailed mapping of stratigraphic relationships and brecciated zones is interpreted to indicate a series of reverse faults. The Stanley Fault (vertical) brought the upthrown SE block of older Precambrian Pedlar into contact with Antietam in the south corner of the hills. Simultaneously, this Antietam was faulted upward by two reverse faults giving approximately 7000' of exposure (stratigraphic thickness ~800'). These were overridden by three reverse faults subsequently bringing up the older Harpers, Weverton, and Catoclin. A NW trending fault occurred along the a-c plane creating visible lineations on ERTS and normal aerial photography.

Fault action emplaced (by lateral secretion) copper on Noak Hill.

A GEOPHYSICAL STUDY IN THE SURRY NUCLEAR POWER PLANT AREA, VIRGINIA. J. B. Dischinger\*, C. M. Isaacs\*, R. E. Van Nieuwenhuise\*. Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

A simple Bouguer gravity map was made for the area defined by latitudes 37°00'00" and 37°18'00", longitudes 76°37'30" and 77°00'00". The map is based on 320 observations, and contoured at an interval of one milligal. The map shows two major anomalies in the vicinity of the Surry nuclear power plant: a gravity high and a low. Both anomalies trend NE-SW. If these anomalies solely reflect density contrasts caused by variations in the topography of the basement, then quantitative interpretation suggest a basement relief of about 2000', which may be due to faulting.

Three vertical electrical resistivity soundings (VES) were made in the area to test the validity of the gravity interpretation. Interpretation of these soundings suggests that there is an increase in the thickness of the sedimentary rocks associated with the gravity low. However, in the absence of resistivity data from wells drilled to the crystalline basement, the interpretation of V.E.S. and gravity data are ambiguous.

Although the interpretations presented here are not conclusive, they point to the possible existence of a major fault in the vicinity of the Surry nuclear power plant, and the need for further investigation based on seismic surveys and control from wells drilled to the basement complex.

KARST GEOLOGY AND GEOLOGIC PLANNING CONSIDERATIONS IN HALL'S BOTTOM, WASHINGTON COUNTY, VIRGINIA. Joseph H. Fagan\*, and Gregg A. Hollomon\*. Dept. of Geology, Emory and Henry Col., Emory, Va. 24327

Hall's Bottom is a karst area located 5 miles east of Bristol in a rural section of Washington, Co., Va. underlain by limestone and dolomite of Cambrian and Ordovician age. The area is drained by Sinking Creek, which enters a cave and flows underground for 1.15 miles before resurfacing at Preston Spring (confirmed by dye trace). Jointing is predominately at 30 and 295; this controls cave formation. During periods of heavy rain, flooding takes place when the stream flow exceeds the capacity of the cave conduit. Increased runoff associated with land development may increase the frequency and extent of these floods. A fence barrier should be placed some distance from the cave to prevent flood debris from blocking the entrance. A relatively thin soil makes groundwater pollution a constant threat. The present agricultural land use should be maintained because of its low impact on this sensitive area.

RATES OF DENUDATION FOR SELECTED VIRGINIA BASINS. W. F. Kane\*, Madison Col., Harrisonburg, Va. 22801

Apparent changes in denudation rates may be useful in determining the effect of man's influence on the land. The largely rural Rappahannock River Basin shows a decrease in the denudation rate from .95 in./1000yrs. to .87 in./1000 yrs., over a period of about twenty yrs. A decrease in solid load of 24% is responsible for this. Dissolved load, on the other hand, rose 30%. This increase is, perhaps, largely due to air pollution, fertilizers, human wastes, and other sources which add significant amounts of  $SO_4^{2-}$ ,  $Cl^-$ , and  $Ca^{++}$ .

Basin size is an important factor in denudation rates. The Rappahannock Basin, with an area of 616 square miles at Remington, Va., has a very small denudation rate when compared to smaller basins such as Smlax Branch and Stave Run near Reston, Va. The latter have denudation rates of 10.84 in./1000 yrs., and 53.45 in./1000yrs., and areas of .32mi.<sup>2</sup> and .08mi.<sup>2</sup> respectively. Chemical erosion in the small basins is a relatively insignificant part of the total load when compared to the role it plays in the Rappahannock Basin where it is one third of the total load.

One further factor involves the amount of construction activity underway in a given basin. While no exact figures are available the percentage of disturbed area in the Smlax and Stave Run Basins appears to significantly exceed that for the Rappahannock.

SCAPOLITE AT ROCK CASTLE, VA. M.G. Mosley\*. Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

Scapolite, var. mizonite, occurs in a Ca-, Mg-, Al-silicate assemblage in layers and blocks arranged parallel to the foliation in a gneiss exposed at Rock Castle, Goochland Co., Va. Scapolite is abundant within the unit, found both with epidote as small veins and interspersed with diopside, actinolite, biotite, grossularite, microcline, quartz, calcite, sphene, and zircon. The white scapolite grains are anhedral to subhedral and macroscopic.

As determined by a least squares refinement of X-ray diffraction data, the scapolite unit cell has dimensions of  $a=12.14(3)\text{\AA}$ ,  $c=7.57(4)\text{\AA}$ , and a volume of  $1116(5)\text{\AA}^3$ . The indices of refraction as measured with index oils are  $N_x=1.582$  and  $N_y=1.556$ . Comparison with crystallographic data of previous workers indicates a composition of 58% melonite agreeing within statistical limits with the composition of 64% melonite as determined by index of refraction measurements. The average composition of 60-62% melonite is within the range of mizonite.

The associated diopside has a composition of  $45\text{Ww}$ , 46Z En, 9FeFs, with unit cell dimensions of  $a=9.74(3)\text{\AA}$ ,  $b=8.92(3)\text{\AA}$ ,  $c=5.25(2)\text{\AA}$ , and  $\beta=105.947^\circ(2)$ , and a cell volume of  $439(2)\text{\AA}^3$ .

Paragenesis indicates a siliceous, dolomitic limestone metamorphosed to the amphibolite facies.

THE SEDIMENTATION FLUME AT MADISON COLLEGE. P. W. Harlema\*, Dept. of Geology, Madison Col., Harrisonburg, Va., 22801

Madison College is presently constructing a sedimentation flume for use in teaching and research. The flume will be used to demonstrate how sedimentary structures seen in ancient rocks can be formed under different flow regimes. Such features as plane beds, ripples, cross laminations, graded bedding, deltas, dunes and antidunes can be produced. Research on the effect of water flow on grain orientation and size sorting can also be performed.

The flume will be a nonrecirculating type that has a sediment trap at the exit end to prevent sand from returning through the pump to the head of the flume. In this type of flume, sediment discharge can be more accurately controlled than in recirculating flumes, and pump life is increased. The  $1 \times 2 \times 18$  foot test channel will be constructed of one-half inch plexiglass and will be supported by a wood truss with a pivot at the head and a hydraulic jack at the exit end.

Water circulates from the pump to the head box, which eliminates turbulence; it then flows through the test channel and falls into the sediment trap. The overflow runs into the sump that feeds the pump. Flow rates will be adjusted by a valve and flume slope by the jack. Sediment transport can be measured by weighing trapped effluent.

PETROLOGY OF THE DIAMOND HILL MEMBER, EDINBURG FORMATION: A MARINE CLASTIC CARBONATE STUDY. J.L. Mincks\*, Dept. of Geology, Coll. of William and Mary, Williamsburg, Va.

The Diamond Hill Conglomerate (Lowry, 1972) is a monomictic clastic limestone unit within the "Liberty Hall" shale lithofacies of the Middle Ordovician Edinburg Formation and is exposed in the northwest limb of the Catawba Syncline near Fincastle, Virginia. Rock type of the unit is intrasparaditic and closely resembles the Pierce Chapel conglomerate of McGuire (1970) within the same stratigraphic interval in the Syncline.

Based on field evidence, and petrographic data the unit consists of two subunits: (1) a lower conglomerate interbedded with graptolitic silty shales and (2) an upper massive conglomeratic unit. Small-scale scour channel development in the upper conglomeratic unit shows erosional bottom contacts and poorly developed loadcasts. Convolute shales of the lower unit are due to backthrusting during post-depositional folding.

Three stages of diagenesis are evident: (1) initial phase deposition in the original site of limeclast formation; (2) after deposition at low Eh values and (3) cementation in remaining pore spaces followed by partial recrystallization throughout the Diamond Hill conglomerate.

Results of this study suggest that the Diamond Hill is a submarine turbidite-like emplacement in a semi-enclosed basin deriving source material from a nearby Edinburg Formation limestone source area.

THE SOUTHERN HALF OF A DOMEAL STRUCTURE IN THE EASTERN PIEDMONT OF VIRGINIA, Leslie J. Parsons\*, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

Previous mapping north of the James River in Goochland, Hanover, and Louisa counties in Virginia has revealed gneissic units occurring in what appears to be the northern half of a domeal structure. An axis of metamorphism trending north-northeast marks the center of this dome.

Reconnaissance mapping of the Powhatan and Pine Creek Mills 7 1/2 minute quadrangles in Powhatan county displayed a deeply weathered gneiss unit bounded on the east by Triassic sediments. Exposures of mica schist occur on the western flank of the dome.

Foliation, parallel or sub-parallel to bedding, strikes northwest and dips southwest in the western half of the Pine Creek Mills quadrangle; it strikes northeast and dips southeast in the eastern half of that quadrangle. Lineations have a gentle southward plunge. In the Powhatan quadrangle on the western edge of the structure, folding and deformation become more complex, but remain on strike with the regional trend. Foliation on the western flank of the structure dips steeply, suggesting overturning.

No units corresponding to the Setters and Cockeysville formations of the Baltimore area have been found. The end of the dome shown by attitudes of foliation corresponds to a similar closure of the aeromagnetic contours.

SEDIMENT TRAPPING EFFICIENCY OF STRAW BARRIERS AND THE RESULTING EFFECT ON WATER QUALITY. David Foche\* and J. O. Phillips, Va. Highway & Trans. Res. Council, Charlottesville, Va. 22901 and Madison Col., Harrisonburg, Va. 22801

The sediment trapping efficiency of hay and straw barriers used for highway construction was tested using a flume. Efficiencies ranged from 47% to 89%. The student t test on results from several types of hay and straw indicated that, on the average, there is no difference between the two materials.

Trapping efficiencies were observed to be much lower in the field due to (1) use of an insufficient number of barriers to meet theoretical soil losses, (2) undercutting, and (3) end flow.

A field test was conducted in the Piedmont region of Virginia to test differences between the currently used barriers and those specifically modified to increase field trapping efficiency. Tests indicated that improperly maintained barriers could actually increase the suspended solids loads during runoff. There was a two- to eightfold increase in the trapping efficiency of the modified barriers when compared with that of the barriers currently used. Trapping efficiency for the 15 barriers used in the test was an average of 57% loss across each barrier.

Use of biological substrates showed significant upstream-downstream differences in the number and kinds of organisms present with the unmodified barriers and no significant differences with the modified barriers.

THE GEOLOGIC EVOLUTION OF GROVE CREEK, VA. S. E. Rickles\* and G. H. Johnson, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

Grove Creek, a small tidal tributary of the James River, is located in James City County, Va. The creek flows from 7 m to sea level in 2.9 km. *Spartina* marshes, which dominate the lower course of the stream, are succeeded upstream by swamp and floodplain environments. A small bar constricts the mouth of the creek. The valley fill, determined from numerous engineering borings and a major dam excavation, consists of a lower sequence of massive cross-bedded sand and silt and laterally equivalent clayey sand, and an upper organic-rich clay. Tree trunks and smaller plant remains are abundant throughout the sequence. The valley fill is 1 m thick upstream and is more than 25 m thick at the mouth of Grove Creek.

During Woodfordian time the mouth of Grove Creek was eroded to below -25 m. As sea level rose during late Wisconsinan and early Holocene time, the lower reaches of the valley were progressively filled with paludal and alluvial deposits. By 4650±250 years B.P., the midcourse of the creek was filled to -4 m with channel and floodplain deposits. Since then, 6 m of additional sediments, including a surficial blanket of organic-rich plastic clay 2 m thick, were deposited. Beach erosion along the James River has shortened the creek during the Holocene.

This study was supported by grants from Busch Properties and the College of William and Mary Minor Research Fund. M. Rubin, U.S.G.S., provided the radiocarbon data.

## Section of Materials Science

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

SOME FEATURES OF IONIC AND ELECTRONIC TRANSPORT IN POLYMERS. R. E. Barker, Dept. of Materials Science, University of Va., Charlottesville, Va. 22901.

In polymers both electrons and ions contribute to the total conductivity  $\sigma$ , however in a given case it is likely that one type of conduction will heavily predominate. For typical polymers such as polystyrene and cellulose acetate ionic conduction is likely to be much larger than the electronic but sometimes it is surprisingly difficult to tell from usual experimental data of current vs temperature and field intensity whether the predominant mechanisms is electronic or ionic. The non-ohmic current-voltage characteristics give some useful but ambiguous clues. Two other useful approaches are to consider (1) the effect of pressure or stress on  $\sigma$  and (2) the influence of absorbed moisture on both the dielectric properties and on  $\sigma$ . Some more evidence is discussed in support of the weak electrolyte model of Barker and Sharbaugh which was developed for organic liquids but also appears to work well for solid polymers.

AN EXPERIMENTAL INVESTIGATION OF THE MELTING BEHAVIOR OF VERY SMALL TIN CRYSTALLITES. R. A. Bylles\* and W. A. Jesser, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Initial experiments employing dark field microscopy of small tin crystallites heated in an electron microscope showed that their melting temperature is well below that of bulk tin and decreases with decreasing size. Upon conducting additional experiments, it was found that the pressure in the specimen area of a conventional transmission electron microscope was sufficient to cause some oxidation of the tin crystallites. In order to conduct a meaningful study of the melting behavior of the crystallites an auxiliary pumping system with cryogenic trapping was attached to a specially designed specimen chamber. This chamber allowed an improvement in vacuum of several orders of magnitude and provided for *in situ* deposition of the tin. Preliminary experiments conducted in the improved environment showed that the tin crystallites may initially form in an amorphous state.

SPLAT COOLING OF DENTAL ALLOYS. G. S. Cutler\* and L. B. Johnson, Jr., Dept. of Materials Science, University of Va., Charlottesville, VA 22901

Various techniques of splat cooling were investigated as to application in the preparation of dental amalgam. Work was concentrated on Ag binary and ternary alloys. Results were obtained in tensile fracture stress, corrosion resistance, and dimensional change during setting as a function of other alloy preparation methods.

THERMAL CONDUCTIVITY VERSUS PRESSURE AND ANHARMONIC FORCES IN POLYMERS. Randall S. Frost\* and R. E. Barker, Jr., Dept. of Materials Science, University of Va., Charlottesville, VA 22901

The influence of pressure on the thermal conductivity  $K$  of four vitreous poly(alkyl methacrylates), PMMA, PEMA, PnBMA and PiBMA, has been measured by steady state techniques. The measurements were made under pressure between 1 and 2030 bars and over a temperature range extending from -100 to 30°C. For each polymer the thermal conductivity was found to increase as the pressure was increased. Thermal conductivity maxima and deflection points were shifted to higher pressures corresponding to  $\partial T/\partial p = 25, 26$  and  $16$  °C/kbar for PMMA, PEMA and PnBMA. A theoretical model for the pressure dependence of  $K$  is shown to lead to a very simple expression  $\Delta K/K = \gamma_G^2 (1 - \exp(-p/B^*))$  where  $\gamma_G$  is the Grüneisen parameter,  $B^*$  is the fractional free volume and  $B^* = kTg/V_G$ . The results of our work imply that the polymeric glassy state is not in true thermodynamic equilibrium.

SLIP GEOMETRY AND FRACTURE IN  $\alpha$ -Fe SINGLE CRYSTAL WHISKERS. R. M. Gardner\* and H. G. F. Wilsdorf, Dept. of Materials Science, University of Va., Charlottesville, VA 22901

Single crystal iron whiskers have been grown by the reduction of ferrous halides by hydrogen. These crystals have been strained to fracture at room temperature and the subsequent slip geometry and fracture surfaces have been observed in the Scanning Electron Microscope. The active deformation modes have been characterized by use of the x-ray precession method. Whiskers were found to exhibit three stage work hardening and these curves depict uniformly spaced, multiple serrations. The complex nature of deformation preceding fracture was exemplified by the observation of slip asymmetry, "unexpected (110) slip", and twinning.

Whiskers exhibited ductile properties and in all cases failed by a large reduction in area.

IN-SITU RADIATION DAMAGE IN A HIGH VOLTAGE ELECTRON MICROSCOPE. J. A. Horton\* and W. A. Jesser, Dept. of Materials Science, University of Va., Charlottesville, VA 22901

The severe environment of fast breeder and controlled thermonuclear reactors causes many materials problems. Various techniques for simulation of this radiation environment are discussed. Two commonly used techniques are ion and electron irradiation. An ion accelerator was attached to the side entry port of the University of Virginia high voltage electron microscope in order to conduct in-situ ion and electron damage experiments. A heating stage was built for studies at temperatures up to 800°C. The radiation damage produced by helium ions near 100 kV is compared to that damaged obtained in similar samples by electron bombardment. Initial experiments conducted on vanadium, stainless steel, nickel, and aluminum indicate that the ion bombardment produces additional effects which are currently under study.

TEMPERATURE DEPENDENT PROPERTIES OF LAMINATED POLYAMIDES. J. Kennedy\* and W. W. Stinchcomb, Dept. of Engr. Sci. and Mech., Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061.

Two reinforced composite materials (a polyimide with graphite reinforcement and a polyamide with glass reinforcement) are examined by use of the short beam shear test to determine selected material properties. Data is presented for test temperatures from room temperature to 600°F for the polyimide matrix material and from room temperature to 450°F for the polyamide matrix material. Included is data on the temperature dependence of stiffness-strength correlation. The analysis is extended to examine the test data from the classical short beam shear test in view of the laminated construction and reinforcement of the specimen and it is found that, in some cases, the strengths predicted by the standard analysis are in error.

This work was supported under NASA Contract No. NAS1-13175.

DETERMINATION OF THE ELASTIC MODULI FOR ORTHOTROPIC FIBER REINFORCED COMPOSITE MATERIALS. R. D. Kriz\* and W. W. Stinchcomb, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst. and St. Univ., Blacksburg, VA. 24061

Three dimensional transversely isotropic materials properties are calculated for a fiber reinforced composite laminae. Modification of present formulas for calculating three dimensional material properties allows one to include the transverse isotropic nature of the fibers. The modified formulas were discovered to give improved bounds for the special case of an isotropic fiber. The paper presents the basic concepts for the formulation of necessary relationships between elastic constants and the methods of solution. The results are presented to show the dependence of the various three dimensional properties on the fiber volume fraction of the laminae.

A PHOTOGRAPHIC TECHNIQUE FOR PREPARATION OF ELECTRON MICROSCOPE SAMPLES OF ARBITRARY GEOMETRY. D. Lashmore† Dept. of Materials Science, University of Va., Charlottesville, VA 22901

A technique for preparing specimens for *in situ* tensile testing in an electron microscope is described. The technique is unique in that specimens can be prepared in the form of a narrow strip with parallel edges which, in tension, exhibit a uniaxial shear stress. The technique is also applicable to many other areas in Materials Science where microfabrication problems exist.

A COMPARATIVE STUDY OF SOME SUPERCONDUCTING PROPERTIES OF 2H-NbSe<sub>2</sub> SINGLE CRYSTALS GROWN BY DIRECT AND IODINE VAPOR TRANSPORT PROCEDURES. N. E. Lewis\*, Dept. of Materials Engr. and Science, T. E. Leinhardt, Dept. of Physics†, and J. G. Billard, Dept. of Chemistry†.

Significant differences have been observed for some of the superconducting properties of 2H-NbSe<sub>2</sub> single crystals grown by direct vapor transport (DVT) and iodine vapor transport (IVT) procedures. The residual resistance ratios (300°K/7.3°K) for the DVT and IVT crystals were observed to be 140 and 40 respectively. The critical current density at zero temperature was estimated to be a factor of ten higher for DVT than IVT crystals. The transition temperature at zero current density was estimated at 7.1°K for the DVT's and 7.25°K for the IVT's.

X-ray diffraction studies indicated both were in the 2H-layer modification. Neutron activation analysis indicated little or no iodine was present in the DVT crystals whereas 400-600 ppm was found in the IVT crystals. Photoelectron spectroscopy studies indicated differences in the quantity of oxidized Nb for the two types of crystals and that the iodine in the IVT's may exist in the I<sup>-</sup> state.

The defects associated with iodine and the way it exists in the lattice is believed to be the major factor for the differences observed.

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COMPUTER ANALYSIS OF X-RAY SPECTRA FROM AN ENERGY DISPERSIVE SPECTROMETER. C. R. Murray\* and M. A. Jessor, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901

A hard wired interface was built between the parallel printer output of a Northern Scientific 600 multichannel analyzer and a Hewlett Packard 2114 minicomputer with a graphics terminal. Spectral data generated by the x-ray detector of an energy dispersive spectrometer may be processed as it is read from the MCA. Currently working data handling programs include ones which smooth and scale the data, locate and identify x-ray peaks according to energy, calibrate the spectrometer and integrate peak intensities between specified locations. The various problems associated with processing spectra from scanning electron microscopes are compared with those from a high voltage transmission electron microscope and a conventional transmission electron microscope.

MORE NEW CARBON MATERIALS. E. L. Olcott, R. G. Shaver. General Technologies Div. of Versar Inc., Springfield, VA 22151

New developments in carbon composite materials for special applications are discussed. Binary carbon alloy systems C-SiC and C-TiC, made by chemical vapor deposition techniques, have lesser anisotropy and improved mechanical properties compared to conventional pyrolytic carbon. Maximum deposition temperature for C-SiC is 2000°C whereas TiC can be codeposited up to 2200°C. The higher deposition temperature results in a more graphitic crystal structure and a less reactive material.

Hollow carbon microspheres (50 µm dia) have been used in composites capable of high strain in compression. Being relatively insensitive to temperature, these composites are useful for high temperature gaskets. Solid carbon spheres from a fluid bed process have been found useful as a filler in a resin bonded "castable carbon". Cast within a carbon fiber mat, and isotropic composite results with good strength. With suitable additions for improving oxidation resistance such a refractory castable is a candidate for a liner material in coal liquification equipment. Resistance to high temperature, corrosive slags and particle impaction are requirements for the larger components required in coal conversion. Several of the carbon developments are under evaluation as bio implants. C-SiC pins have been implanted for tooth retention devices. The "castable carbon" has been used successfully as a permanent internal splint for broken wings of geese. The broad range of properties available from these carbon materials along with their established biocompatibility appear attractive for a biomaterial.

FRACTURE IN POLYCRYSTALLINE BERYLLIUM. T. C. Pollock\* and H. G. F. Wilsdorf, Dept. of Materials Science, University of Va., Charlottesville, VA 22901

Tensile specimens prepared from rolled polycrystalline beryllium sheet were fractured inside a 500 kV transmission electron microscope. The fracture phenomena observed involved both ductile and brittle behavior. The relative importance of grain boundaries and sub-boundaries in crack initiation is considered. Observation of advancing cleavage cracks indicates that the region surrounding the crack tip suffers elastic strain, but no plastic deformation.

IN SITU OBSERVATIONS OF CRYSTAL GROWTH AND MASS TRANSPORT IN A SCANNING ELECTRON MICROSCOPE AS APPLIED TO AMALGAMS. C. L. Reynolds, Jr., F. E. Wawner\*, and H. G. F. Wilsdorf, Dept. of Materials Science, University of Va., Charlottesville, VA 22901

In the course of an investigation on the amalgamation process, *in situ* observations were made in a scanning electron microscope (SEM) of crystal growth and mass transport in amalgams. These observations were carried out by the examination of fracture surfaces of the test specimens. The crystals were identified by energy dispersive x-ray analysis.

When Ag<sub>3</sub>Sn is triturated with mercury, a pliable mass is initially formed which hardens within minutes. It is well established that unreacted Ag<sub>3</sub>Sn particles (γ) embedded in a matrix of Ag<sub>2</sub>Hg<sub>3</sub> and Sn<sub>7-8</sub>Hg are the primary phases in the resultant amalgam (called γ<sub>1</sub> and γ<sub>2</sub> respectively). While the initial and final stages of the amalgam have been known for some time, the intermediate stages of the amalgamation process have not been documented.

THE DEVELOPMENT OF NEUTRAL GAS BEAMS WITH SATELLITE VELOCITIES FOR SURFACE INTERACTION STUDIES. Alpha Smith, NASA-Langley Research Center, and George Sanzone, Dept. of Chemistry, VPI & SU

Many satellite and entry experiments have experienced serious measurement problems which have been associated with reactions of atmospheric gases with exposed surfaces. Recent achievements in upper atmospheric and interplanetary flight have also emphasized a need for comprehensive data on the nature of gas-surface reactions. Consequently, there is a well-documented need for well-characterized but easily-formed ion beams with particle speeds of about  $10^6$  cm sec<sup>-1</sup>.

Ion beams have been prepared in the past by charge-exchange, but the presence of metastable ions in such beams has not been extensively studied or exploited. In this paper, we report on a program directed at the study and characterization of oxygen ion beams. Contributions of metastables to charge exchange cross sections are treated. Applications of beam-formation techniques and charge-exchange data to the study of gas-surface interactions are discussed.

EFFECT OF MATERIAL NONUNIFORMITY ON RESPONSE OF NUCLEAR-RELATED PRESSURE VESSELS. G. Subbaraman\* and K. L. Reifsnider. Engr. Sci. & Mech. Dept., Va. Poly. Inst. & State Univ., Blacksburg, VA 24061

Stainless steel alloys proposed for fuel cladding of the Liquid Metal Fast Breeder Reactor (LMFBR) are known to degrade under longtime exposure to liquid sodium at high temperature and high neutron flux. This degradation is known to be nonuniform through the thickness of the tube. A stress analysis of such a tube under pressures of 800 psi, as might be encountered in the gas plenum portion in the LMFBR, is carried out, with allowance for spatially varying material properties. A closed form solution to the equations of equilibrium with cylindrical symmetry is obtained for the simple form  $f(r) = 1/r$  for the spatial variation. Variation of the results from earlier treatments are discussed.

AN INVESTIGATIVE STUDY OF CRACK INITIATION PHENOMENA. A. Talug\* and K. L. Reifsnider. Engr. Sci. & Mech. Dept., Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061.

In many important common situations, crack initiation constitutes most of the fatigue failure process. While much attention has been directed to the metallurgical aspects of initiation, relatively little attention has been given to the phenomenon as a mechanics problem. The present paper considers a combination of data produced by scanning electron microscope study of fatigue initiation sites and by an analysis of stress fields around a short edge crack in a plate. Special attention is given to the effect of the near surface on stress field development and subsequent initiation behavior.

STRESS ANALYSIS BY STRESS-HOLO-INTERFEROMETRY. Y. T. Yeow\* and H. F. Brinson. Dept. of Engineering Science and Mechanics, Blacksburg, Va. 24061.

A brief but concise description of holographic interferometry in general, and stress-holo-interferometry or holographic photoelasticity in particular, is given. Also the analytical development of an infinitely long strip with a symmetrically or unsymmetrically located hole under either uniaxial tension or four point bending is described. These two theoretical problems are verified experimentally with an interferometer which utilizes a double pass laser system to acquire the isopachics and isochromatics simultaneously. Comparison between experiments and theory are demonstrated only for two-dimensional cases. However, extensions to three-dimensional cases are discussed. The advantages and limitations of the double pass interferometer are evaluated.

## Abstracts of Papers Section of Medical Sciences

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

THE CHICKAHOMINY INDIAN TRIBE AS MATERIAL FOR MEDICAL GENETICS STUDIES. Robin J. Caldwell\*, J. Ives Townsend, and M. J. V. Smith. Program in Human Genetics and Div. of Urol., Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298

The Chickahominy Indian tribe is a small, relict population now scattered mostly in Charles City and New Kent Counties, Virginia. In spite of living among other peoples for more than 350 years, this population appears to have maintained considerable biological isolation. First and second cousin marriages are rather common. As a result, 330 of the 852 Chickahominy Indians now known to us and included in our 5-generation pedigree have the surname, Adkins; 68, Cannada (or Canada); and 74, Holmes. Consanguineous unions have sometimes resulted in offspring affected with defects of known autosomal recessive genetic etiology, such as cystinuria and propionic acidemia. Further investigation is expected to relate the level of inbreeding and the prevalence of these and other genetic abnormalities in this unusual population. (Supported in part by an A. D. Williams research grant.)

THE EFFECTS OF GLUCAGON, EPINEPHRINE, AND INSULIN ON PROTEIN DEGRADATION IN MOUSE ORGANS. W. E. Duncan\* and J. S. Bond. Dept. of Biochemistry, Va. Commonwealth Univ., Richmond, Va. 23298

The aim of this research is to develop a method to directly measure the effects of hormones on protein degradation in mouse lung, heart, intestine, spleen, liver, kidney, and skeletal muscle. Using the double label isotope technique of Arias et al. (1969) (J. Biol. Chem. 244: 3303), a method of determining relative half-lives of supernatant and particulate proteins of several mouse organs has been developed. Organs were homogenized in an isotonic  $\beta$ -glycerophosphate buffer, pH 7.2, and supernatant (SUP) and particulate (PPT) fractions were separated by centrifugation at 48,200  $\times$  g for 2 hrs. Proteins were precipitated by 5% trichloroacetic acid and washed with ethanol-ether solutions before radioactivity was determined.

Preliminary data from these experiments show that glucagon (0.42 to 2.0 mg/kg) increases protein degradation in intestine SUP and PPT, spleen SUP and PPT, and muscle SUP proteins. Insulin (0.8 to 5.8 units/kg) decreased protein degradation in intestine PPT and liver SUP proteins. Epinephrine (0.07 to 0.65 mg/kg) decreased protein degradation in lung PPT, intestine SUP and PPT, liver PPT, and kidney SUP proteins. The effects of these hormones on other tissues could not be determined. Average error among the control group was 8%. These experiments are the first to demonstrate the effects of these hormones on protein degradation by a direct isotopic method. (Supported by the Amer. Cancer Soc. (IN-105)).

STAPHYLOCOCCUS AUREUS INHIBITION BY LOW DIRECT CURRENT ON SILVER ELECTRODES IN THE FEMUR OF RABBITS. G. Colmano, and S. D. Barranco, Dept. of Vet. Sci., VPI & SU, Blacksburg, VA 24061, and Montgomery County Orthopedic Associates, Blacksburg, VA 24060.

Control of possible accidental surgical room contamination with coagulase positive, penicillin resistant *Staphylococcus aureus* was sought by using the bacteriostatic effect of free ionic silver. From silver pins, inserted into the marrow of the femurs of rabbits through the femoro-tibial articulation, silver ions were freed by 3 and 9  $\mu$ AH/mm<sup>2</sup> direct positive current. A negative silver lead was implanted as ground on the tibial face of the right leg. Each animal was used as its own control, with both legs pinned and contaminated by 0.1 ml of a *Staph.* culture ( $10^8$  bact./ml), but with only the right leg treated with the current. After 6 days the rabbits were sacrificed. The pins were removed and processed to determine their bacterial concentration. The bacteriology plates from the right legs, treated by current, as compared to the untreated left legs, informed us that the current treatment on the *Staph.* contaminated pins inserted into the femurs of the rabbits lowered the bacterial count, and that the increase from 3 to 9  $\mu$ AH/mm<sup>2</sup> resulted in an increase in the bacteriostatic effect. The observed bacteriostatic effect was significant enough to almost eliminate the chance of clinical infection resulting from *Staph.* contamination through orthopedic pins.

ANALYSIS OF TRYPTOPHAN LEVELS IN SERUM AND CATARACTOUS LENS OF TRYPTOPHAN-DEFICIENT WEANLING RATS. Gregory M. Fillinov\*, George E. Bunce\*, and John L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Methods and determinations of biochemical changes that accompany cataract formation in weanling Sprague-Dawley rats will be discussed. The rats were fed a deficient (0.05%) tryptophan diet for ten weeks. The incidence of cataract formation in the tryptophan-deficient animals was 85%. The level of free tryptophan in the serum of the deficient animal dropped to nearly one-third the level of the control animal and the level of free tryptophan in the lens dropped to nearly one-half. The ratio of soluble protein versus insoluble protein in the lens of the control animal was approximately 3:1, whereas it dropped to a 1:1 ratio in the cataractous animal. The implication of these results toward the mechanism of cataract formation will be discussed. (Supported by PHS-EY01060 - National Institutes of Health)



AN UNEXPECTED RELATIONSHIP BETWEEN THE FORMATION OF THE  $\alpha$  AND  $\beta$  CHAINS OF HEMOGLOBIN. M.D. GARRICK and L.M. Garrick, Dept. of Biochem., State University of N.Y., Buffalo, N.Y. 14207

Understanding the relation between formation of  $\alpha$  and  $\beta$  chains of hemoglobin is critical to developing rational management of the thalassemias. The  $\beta$  globin chain of certain rabbits contains no isoleucine while the  $\alpha$  chain contains three isoleucyl residues. L-0-methylthreonine, an isoleucine isostere, inhibits incorporation of radio-labeled amino acids into  $\alpha$  chains by rabbit reticulocytes. When  $\alpha$  chain synthesis is inhibited by 50-85%,  $\beta$  synthesis is stimulated by 15-50%. The stimulation does not occur when 1mM 2-mercaptoethanol is added to the incubation or when the cells are excessively diluted. Elongation of  $\beta$  chains increases more than initiation although both are speeded up during stimulation; suggesting that initiation is the rate limiting step in increased  $\beta$  chain production. The unexpected stimulation of  $\beta$  synthesis is interpreted as resulting from relief of competition between  $\alpha$  and  $\beta$  mRNAs for limiting components of the protein synthetic apparatus.

BIOLOGICAL FORMATION OF KIDNEY STONE NUCLEI IN VITRO. William E. Keefe, Dept. of Microbiology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23220.

It has been shown that several species of bacterium which have been isolated from the urine or kidneys of patients suffering from kidney stones have the ability to form intracellular crystalline deposits of materials which have the same composition as the inorganic portion of kidney stones.

NEURONS OF THE CAUDAL NEUROSECRETORY SYSTEM IN FISHES. R. M. Kriebel\*, G. D. Meetz, and J. D. Burke. Dept. of Anatomy, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298.

In all teleosts studied to date, neurosecretory cells occur in the caudal region of the spinal cord. It is the intent of this report to discuss the neurosecretory cells observed in three species currently studied in our laboratory, namely, *Pomatomus saltatrix* (bluefish); *Pomolobus aestivalis* (herring); *Mollienisia latipinna* (mollie).

The neurosecretory neurons are easily recognized by their large size and lobed nuclei. Notable in the bluefish and herring is the juxtaposition of the capillaries and the perikarya of the neurosecretory cells. This specialized neuron is being studied in the mollie with electron microscopy. The perinuclear cytoplasm of these cells is filled with electron dense granules. In the urophysus of the mollie, caudal neurosecretory system granules of this nature are observed in the axon terminals of these cells.

Supported by A. D. Williams Grant 3558 (505).

MICRO-METHOD FOR MEASURING ACETYLCHOLINE TURNOVER IN BRAIN TISSUE IN VIVO. M. Karbowska\*, A. Jagoda\*, W.L. Dewey, and L.S. Harris, Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298

Our knowledge of cholinergic function in the central nervous system has been hampered by the lack of a sensitive and reliable method for measuring the turnover rate of acetylcholine (ACh) in the brain. Thus, we have developed a technique by which one can accurately measure the *in vivo* conversion of a radioactive precursor (choline) into product (ACh), and arrive at the synthesis rate of ACh. Mice were sacrificed by decapitation at various times after the *i.v.* injection of 10  $\mu$ Ci Me-3H choline (Ch). The brains were removed and homogenized in formic acid/acetone within less than one minute. 3H-Ch and 3H-ACh were separated from 3H-choline phosphate (CP) by extraction into tetraphenylboron in heptanone. Subsequently, 3H-Ch was separated from 3H-ACh by first converting Ch to CP using choline kinase (E.C.2.7.1.32) in the presence of ATP, followed by the extraction of ACh into tetraphenylboron in heptanone. Endogenous levels of ACh and Ch were determined by the method of Goldberg and McCann (J. Neurochem. 1973). Knowing the specific activity of Ch and the amount of ACh (dpm/g) at different times, the rate of ACh formation *in vivo* was calculated. Using these techniques, we have determined the initial velocity of ACh formation to be about 15 nmoles/min/g, yielding a turnover time of approximately one min. Only 20 mg of tissue are needed for this procedure. (Supported by USPHS Grant #DA00326 and DA00490).

Enhancement of 5-Fluorouracil Toxicity by Adrenergic Agents. P.C. Klykken\* and A.E. Munson\*. P. Larson (sponsor) Department of Pharmacology, Med. Coll. of Va., and the MCV/VCU Cancer Center, Richmond, Va. 23298.

The toxicity of 5-fluorouracil (FU) to Nylar-A mice was significantly potentiated by pretreatment (6-24 hr) with 2 mg endotoxin/kg. The LD<sub>50</sub> of FU was 140 (128-153) mg/kg as compared to 68 (59-80) mg/kg for the endotoxin treated mice. The slope of the dose-response curve for FU was 1.578. The survival time of FU treated mice was 4-10 days. Mice were protected from the synergistic response by bone marrow reconstitution, implicating bone marrow as the target tissue. Propranolol (10 mg/kg *i.v.*) administered 30 min. before endotoxin partially reversed the endotoxin - FU synergistic response suggesting a role for catecholamines in this interaction. Isoproterenol (.15-1.2 mg/kg) was able to substitute for endotoxin in this interaction. Increased lethality was most pronounced when isoproterenol (.6-1.2 mg/kg) was administered *i.v.* 2-8 hrs. before FU. Ephedrine (100 mg/kg) administered *i.v.* 4 hrs. prior to FU also potentiated FU lethality. The LD<sub>50</sub> was 115 (103-128) with a slope of 1.291. The potentiated response was parallel to the dose-response curve of FU alone. Ephedrine did not potentiate FU lethality when administered either simultaneously with or at .25, .5, 1, 2 or 8 hrs. before FU. Supported by American Cancer Society Institutional Grant IN-105.

A SAMPLING TECHNIQUE AND THE MICROFLORA OF THE VIRGIN BOVINE UTERUS. J. Clark Osborne, D. F. Watson, T. L. Bibb and J. W. Davis. Dept. of Veterinary Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A sampling technique was sought that would provide a contaminant-free sample of the uterus and fallopian tube in 100% of samples taken. Exposure to the atmosphere (oxygen) must be less than thirty minutes for culture of obligate anaerobes. The bicornate bovine uterus was cultured from samples taken by surgical extirpation of one uterine horn and fallopian tube via left flank laparotomy. Clamping each end with hemostats before excision excluded air from the sample during transit to the anaerobe laboratory. The procedure was used in a study of the microflora of the virgin heifer's uterus. Three Holstein female calves were reared completely separated from males to ages 15 to 18 months. The surgically removed samples (one operation 7 days pre-estrus and the other 7 days post-estrus) did not yield growth in cultures for anaerobes, aerobes, mycoplasmas, spirillae, fungi, and viruses.\* Three sites in each horn plus an endometrial tissue sample and a swab of each fallopian tube were cultured. Histologically the organs were normal. The surgical procedures did not alter significantly the normal 21-day estrus cycle of the heifers. It was concluded that the bovine virgin heifer uterus is sterile.

\*Uteri were shipped in dry ice for virus examination by Dr. C. R. Rossi, Auburn Univ., Auburn, Ala.

THE EFFECTS OF 48 HOUR NICOTINE WITHDRAWAL ON HEART RATE AND RESPIRATION DURING CONTINUOUS MONITORING OF ALL NIGHT SLEEP PATTERNS IN ADULT FEMALES. L. C. Parsons, S. Avery\*, S. Christmann\*, J. Hopkins\*, and M. Seal\*. Sch. of Nursing, Dept. of Physiology, Sch. of Med., Univ. of Va., Charlottesville, Va. 22903.

Four healthy adult female smokers between the ages of 21 and 25 were electrophysiologically monitored for 5 consecutive nights following 1 conditioning night. The effect of 48 hour nicotine withdrawal on heart rate and respiration during the sleep-awake cycle was determined. All subjects exhibited a decrease in mean heart rate during awake conditions of bed rest on nicotine withdrawal nights 1 and 2. Increases in mean heart rate were recorded on nicotine recovery nights. On the second recovery night the mean heart rate values tended to show a return to control levels. The same pattern of change was recorded during light and delta sleep with the exception that on recovery night 2, mean heart rate remained elevated above control values. Respiratory rates during awake, light sleep and delta sleep tended to show patterns of increase in rate in nicotine withdrawal nights with the second withdrawal night showing the lowest value. Following the resumption of nicotine respiratory rates tended to return to control levels during light and delta sleep on recovery nights.

This res. was supported in part by NIH (Div. of Nur) Res. Development Grant #R02-NU00345-04 and Construction Grant #1C05-NU-04225-01.

THE DEVELOPMENT OF TOLERANCE TO THE CHRONIC INTRAVENICULAR ADMINISTRATION OF ACETYLCHOLINE IN MICE. Norman W. Pedigo\*, William L. Dewey, and Louis S. Harris, Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298.

The antinociceptive activity of intraventricular (i.v.) administered acetylcholine in mice has been characterized in our laboratories (JPET, 193, in press). I.v. acetylcholine has been shown to increase the latency in the tail-flick test and inhibit the abdominal stretching response to intraperitoneal p-phenylquinone (ED50 = 7.3 ug and 5.1 ug, respectively). Similarity to morphine antinociception was demonstrated by the development of tolerance to the antinociceptive effects of chronically administered acetylcholine. Mice were pretreated with acetylcholine (8 ug, i.v.) every hour for 1, 2, 4 or 8 hours and tested one hour after the last injection. Tolerance to intraventricular acetylcholine appeared to peak at 4 hours pretreatment and remain high at 8 hours. Tolerance was overcome by a high dose of acetylcholine (32 ug, i.v.) and no significant cross tolerance was observed to morphine (10 mg/kg, s.c.). Mice were also treated chronically with morphine in increasing doses of 10-40 mg/kg, twice daily for 5 days. Significant tolerance to morphine (10 mg/kg, s.c.) and cross tolerance to acetylcholine (8 ug, i.v.) were observed. These data implicate the possible involvement of central cholinergic mechanisms in the development of tolerance to morphine. (Supported by NIH grants Numbers DA-00326 and DA00490).

THE CONTRASTING EFFECTS OF AMINO AND GUANIDINO ACIDS AND ESTERS ON THE ACTIVATION OF PLASMINOGEN BY STREPTOKINASE AND ON THE ACTION OF PLASMIN AND ACTIVATOR. P.S. Roberts\*, R.M. Offenbrite, P.B. Fleming\*, J. Russell\*, and S. Bitting\*. Dept. of Medicine, Med. Col. of Va., Richmond, Va. 23298.

10mM concentrations of benzoic and phenylacetic acids and their ethyl esters, each with an amino, aminomethyl, aminomethyl, guanidine methyl or guanidine ethyl group placed meta or para on the ring, were compared for their effects at 37°, pH 8.0, on the activation of human plasminogen (Pg) by streptokinase (SK) and on the hydrolysis of TAME (p-tolyl-L-arginine methyl ester) by plasmin (PI) and activator (A), the active complex of PI and SK. The amino acids had slight or no effects on the activity of PI or A but some of them, as previously reported, were potent inhibitors of Pg activation by SK. Their ethyl esters also inhibited Pg activation as well as the activity of PI and A. Activation was always inhibited more with low than with high concentrations of SK. In contrast, the guanidine acids did not inhibit Pg activation or the activity of PI or A and the guanidine esters had anomalous effects. One of them inhibited Pg activation more in the presence of a high than a low concentration of SK while two of them accelerated TAME hydrolysis by A but not by PI. It was concluded that compounds with a particular spatial arrangement of the ester and guanidine groups react with SK, changing its activities on various substrates. (Supported by Research Grant, HL-13379, National Heart & Lung Institute, USPHS, Bethesda, Maryland)

THE EFFECT OF 48 HOUR NICOTINE WITHDRAWAL ON ALL NIGHT SLEEP PATTERNS IN ADULT FEMALES. L. C. Parsons, M. Lytle\*, J. Mabe, P. Pollock\*. Sch. of Nursing and Dept. of Physiology, Sch. of Med., Univ. of Va., Charlottesville, Va. 22903.

Four healthy adult female smokers between the ages of 21 and 25 yrs. and having smoked for at least 3 yrs. duration were electrophysiologically monitored for 5 consecutive nights following 1 conditioning night. The effects of 48 hour nicotine withdrawal on the sleep-awake patterns were determined. Stage IV of sleep tended to double on nicotine withdrawal night #1 at the expense of Stage III. On the second nicotine withdrawal night mean values of Stage III and IV (delta stage) remained above control levels. Following a resumption of smoking, delta sleep remained well above control value for the 2 subsequent recovery nights monitored. Two of the 4 subjects were moderately heavy smokers (20 to 30 cigarettes per day) and tended to show higher mean percent time in both Stage III and IV than lighter smokers (subjects that smoked less than 10 cig. per day) on both nicotine withdrawal and recovery nights. The moderately heavy smokers demonstrated an approximate 50% increase in REM burst on nicotine withdrawal nights when compared to control of recovery nights. The maximum variation of REM on any one night regardless of condition was 32%.

This res. was supported in part by NIH (Div. of Nur) Res. Development Grant #R02-NU00345-04 and Construction Grant #1C05-NU-04225-01.

PERIVASCULAR SPACES IN THE PINEAL GLAND OF THE GROUND SQUIRREL, CITELLUS TRIDECIMLINEATUS. J.T. Rovinsky\* and H.R. Seibel. Dept. of Anatomy, Med. Col. of Va., Richmond, Va. 23298.

Punctuating the pineal gland of the thirteen-lined ground squirrel (*Citellus tridecemlineatus*) is a rich capillary network about which lies a prominent perivascular space. This space has been examined at the electron microscopic level and is seen to intervene between the continuous basal lamina of the capillary endothelium and a discontinuous basal lamina adjacent to the outlying pineal parenchymal cells. The capillary endothelium associated with this space is frequently fenestrated, however, on occasion endothelium of the non-fenestrated variety is observed. Within the perivascular space proper, collagen fibrils, neural elements and the processes and bulbous terminals of parenchymal cells are commonly found. The neural elements consist of myelinated and unmyelinated axons as well as numerous axon terminals. These terminals contain an array of vesicle types ranging from spherical, translucent vesicles of 200-600 Å in size, to granular dense core vesicles 600-800 Å in size. The parenchymal processes arise as singular extensions of the parenchymal cell bodies. Their initial segments taper to form a neck-like region which is rich in microtubules and smooth surfaced endoplasmic reticulum, while their distal segments swell into bulbous terminals containing mitochondria, lipid droplets, clear vesicles ranging in size from 200-1,500 Å and occasional dense core vesicles. (Aided by A.D. Williams grant 3558-505 and 509).

THE EFFECTS OF Δ<sup>9</sup>-TETRAHYDROCANNABINOL (Δ<sup>9</sup>-THC) ON LEWIS LUNG CELLS IN CULTURE. A.C. WHITE\*, A.E. WUKOSI\*, J.A. LEWIS\*, L.S. HARRIS, and R.T. CARCERIAN\*. Dept. of Pharmacology, Med. Col. of Va., Richmond, Va. 23298.

Lewis lung adenocarcinoma cells isolated from tumors carried in C57B/6 mice have been established in tissue culture. These cells in culture maintain a transformed phenotype: logarithmic growth is not contact inhibited and population doublings occur at 12.5 hour intervals. Harvested cells injected into the gluteus muscle of mice induce tumors indistinguishable from tumors passed in vivo.

We have used this culture system to assay the antineoplastic activity of Δ<sup>9</sup>-THC. Δ<sup>9</sup>-THC was shown to cause a dose dependent inhibition of cell growth at concentrations below 10<sup>-6</sup>M. To elucidate the mechanism of this inhibition the incorporation of <sup>3</sup>H-thymidine into DNA was analyzed. Δ<sup>9</sup>-THC causes a dose related decrease in DNA synthesis. Uptake of radiolabel in the presence of Δ<sup>9</sup>-THC was similar to that of control cultures. These experiments suggest that the inhibitory action of Δ<sup>9</sup>-THC is distal to the uptake or conversion of DNA precursors. (Supported by NIH grant DA-00490, Alexander and Margaret Stewart Trust Fund, American Cancer Society Institutional Grant, and A.D. Williams Research Fund.)

## Abstracts of Papers

# Section of Microbiology

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

Interactions in vivo Between Antitumor Drugs and Bacteria. Anne C. Adams\*, and S. G. Bradley, Dept. of Microbiology, Virginia Commonwealth University, Richmond, Va. 23298.

Many antitumor drugs render laboratory animals hyperreactive to bacterial endotoxin (END), for example, simultaneous administration of 1 mg of vincristine (VNC) per kg and 1 mg END per kg kills most of the treated mice although neither agent alone does. In this investigation, the VNC-treated mouse has been used as an indicator to assay for endotoxic activity in diverse bacteria and commercial protein preparations. Cells from 10 mucoid strains of *Pseudomonas aeruginosa*, isolated from patients with cystic fibrosis, were harvested by centrifugation, suspended in saline and killed by heating in a boiling water bath for 10 min. Mice were administered a cell-suspension having an absorbance at 420 nm of ca. 10 (0.01 ml per gram of mouse) simultaneously with 1 mg VNC/kg. All 10 strains of *Pseudomonas* possessed endotoxic activity. Moreover treatment of mice with heat-killed *Pseudomonas* rendered the animals resistant to a dose of END that killed untreated mice. Cells from 7 strains of *Bacteroides* were harvested by centrifugation, suspended in saline and frozen. Mice were administered a cell-suspension having an absorbance at 420 nm of ca. 40 (0.01 ml/g mouse). Four of the *Bacteroides* strains possessed endotoxic activity by this assay. All 7 strains were able to evoke resistance to a lethal dose of END. Cells from 10 strains of *Listeria monocytogenes* were examined; about half of these possessed endotoxic-like activity. Seven commercial protein preparations were examined; most of them were contaminated with material having endotoxic activity.

Toxicity, Clearance and Metabolic Effects of Pactamycin in Combination with Bacterial Lipopolysaccharide. S. G. Bradley, and J. S. Bond. Virginia Commonwealth Univ., Richmond, Va.

Combinations of pactamycin and bacterial lipopolysaccharide (LPS) or lipid A complexed to bovine serum albumin, administered simultaneously, killed BALB/c mice synergistically. The enhanced lethality was not the result of a reduced rate of elimination of LPS or pactamycin from the circulation. Pactamycin administered iv, but not ip, accumulated in the lungs immediately after injection; thereafter the drug progressively disappeared from lung tissue. Concurrent administration of LPS did not alter the accumulation of pactamycin in the lungs nor its rate of elimination from blood and lungs. Pactamycin and LPS in combination increased the *in vitro* fragility of hepatic and renal lysosomes, as measured by the release of cathepsin and  $\beta$ -glucuronidase; the effect of the combination was approximately equivalent to the sum of effects of LPS and pactamycin alone. Concanavalin A and cyclic adenosine 3', 5'-monophosphate did not modify the lethality of pactamycin and LPS, singly or in combination whereas caffeine, ethylenediaminetetraacetate, or 6-methylprednisolone protected mice from the lethal action of LPS and the synergistic combination but not that of pactamycin. Lethal doses of LPS and the synergistic combination, but not pactamycin, provoked marked hypothermia and elevated concentrations of blood urea nitrogen (Bradley and Bond. 1975. Toxicol. Appl. Pharmacol. 31: 208-221). These results indicate that pactamycin rendered mice more susceptible to LPS.

ASSESSMENT OF THE HUMORAL IMMUNE RESPONSE IN MALNOURISHED GUINEA PIGS. D. Berlinerman\*, M. R. Escobar and W. Dutz. Dept. of Pathology, Med. Coll. of Va., Richmond, Va. 23298.

The effects of early neonatal malnutrition in a guinea pig experimental model on the maturation of the humoral immune system were investigated. Neonate subjects were divided in 4 dietary groups: suckling, unrestricted, restricted, and starved. Restricted diets lasted 10 days after which *ad libitum* food was given. Subjects were sacrificed 30-46 days after birth.

Tests on sera showed no significant differences regarding total gammaglobulin, IgG, serum protein and hemolytic complement levels among the four groups. There were significant differences in complement component C3 levels between the suckling and the three other groups but no significant differences among the latter. There was a significant difference in serum albumin levels between the suckling and starved groups.

Test results both agreed and disagreed with results obtained by other investigators, because of different parameters of experimentation, time frame for testing, ages of subjects, periods of time of malnutrition, and severity of attendant infections which may influence test results. The present study demonstrated that early malnutrition had a very limited, if any, apparent effect on the maturation of the humoral immune system.

PULMONARY INFECTION DUE TO DISRUPTION OF THE PHARYNGEAL BACTERIAL FLORA BY ANTIBIOTICS IN HAMSTERS. H. P. Dalton, M. M. Muhovich, M. R. Escobar and M. J. Allison. Dept. of Pathology, Med. Coll. of Va., Richmond, Va. 23298.

An animal model was used to determine the effect of oxacillin on the pharyngeal bacterial flora and the relationship of this flora to pneumonia. The pharyngeal bacterial flora of 66 healthy Golden Syrian hamsters was determined. A quantitative comparison between *Streptococci* and *Escherichia*, *Proteus*, *Klebsiella* and *Enterobacter* from 70 hamsters was made before and at 4, 24, 48 and 72 hours after oxacillin administration. Lung cultures were positive in 22 of 25 hamsters, yielding *K. pneumoniae* type I most frequently. Lung histology from 25 hamsters revealed bronchopneumonia. Intestinal postmortem cultures of treated and untreated animals were similar. The importance of throat cultures in diagnosing pneumonia and the value of the hamster model to study the effect of other antibiotics on the temporary flora are demonstrated.

LEVELS OF CYCLIC 3',5'-ADENOSINE MONOPHOSPHATE (cAMP) AND CYCLIC NUCLEOTIDE PHOSPHODIESTERASE IN ADULT, FETAL AND TUMOR CELLS IN VITRO. W. L. Donley, B.A. Weeks and M.R. Escobar. Old Dominion University, Norfolk, and Virginia Commonwealth University, Richmond, Va.

In earlier work we investigated the antigenic relationships among cells in culture derived from normal, fetal and cancerous tissue by indirect immunofluorescence, complement fixation and agar gel diffusion techniques. The results implied an antigenic similarity between the tumor and fetal cells which led us to investigate the differences among these cell types regarding cAMP levels and phosphodiesterase activities. cAMP levels were determined by the Amersham/Searle cAMP assay based on the Gilman competition protein binding technique. Levels of the nucleotide in the tumor cell line were similar to those of the fetal cells (44-63 picomoles/mg protein). However, these levels were 2 to 3-fold lower than those in the normal adult cell cultures (165 picomoles/mg protein). Cells assayed by the method of Thompson and Appleman indicated that cyclic nucleotide phosphodiesterase activities did not differ significantly among the cell lines. These studies seemed to demonstrate that the cAMP levels of these cells paralleled the antigenic similarities noted previously and that phosphodiesterase was not involved in controlling the intracellular level of cAMP in these cell cultures. Studies on the specific activity of adenylate cyclase are now in progress.

MIXED INFECTIONS OF SINGLE CELLS WITH BOVINE PARVOVIRUS AND ENTEROVIRUS. R. B. Dorsey\*, R. C. Bates, and D. S. Parris\*. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Bovine fetal spleen cells synchronized with 2mM hydroxyurea (HU) were infected with bovine parvovirus (BPV) and enterovirus (ECBO) in order to study the events occurring when DNA and RNA viruses mixedly infect single cells. Single infection of cells with BPV upon release from HU does not affect cellular macromolecular syntheses until 8 h post-infection (PI); whereas, single infection with ECBO virus results in a rapid decrease in the rates of total DNA, RNA and protein synthesis by 2 h PI. In mixed infection studies, synchronized cells were preinfected with BPV at 0 h post release (PR) from HU and superinfected with ECBO virus at 8 h PR, a time coincident with the initiation of BPV DNA synthesis. In these mixedly infected cells, the rate of BPV DNA synthesis was reduced by more than 50% as compared to cells singly infected with BPV. A parallel decrease in the rates of total RNA and protein synthesis was also observed in these cells. However, final titers of infectious progeny virus were only 10-fold lower than in singly infected parallel cultures. A similar reduction in BPV hemagglutination titers was also observed. This system demonstrates that under optimal conditions a cell cycle dependent DNA virus can replicate in the presence of a cytotidal RNA virus which rapidly inhibits cellular macromolecular syntheses.

HUMAN OBSERVATIONS REGARDING THE EFFECT OF CHRONIC INFECTION ON CELL-MEDIATED IMMUNITY DURING THE PERINATAL PERIOD. W. Dutz, Dept. of Pathology, Med. Coll. of Va., Richmond, Va. 23298

Fifty orphans in Iran were methodically observed for 3 to 5 years after birth. Weight and growth changes, intercurrent infections, other diseases and general development were carefully monitored. The infants were tested with 2,4-DNCB intracutaneously following previous sensitization. Of the fifty infants 10% were atopic and 40% showed a markedly reduced reaction. A comparison between growth parameters and intercurrent disease in the first year of life and results of the 2,4-DNCB test was performed. All infants who suffered from severe chronic diarrhoea in the first 6 months of life and who produced a radiologically verified atrophy of the thymus for at least 1 month duration were atopic. Infants with less severe disease showed reduced reactions. There was no agreement between weight and growth development or other intercurrent diseases and the persistent atopy. Severe disease after the sixth month of life did not seem to interfere with the development of cell-mediated immunity.

ANIMAL MODELS OF NEONATAL THYMIC ATROPHY. M. R. Escobar, W. Dutz\* and B. Israel. Dept. of Pathology, Med. Coll. of Va., Richmond, Va. 23298

The effect of thymic atrophy, in association with protein-calorie malnutrition, chronic bacterial and viral infection and drug induced immunosuppression on the immune system has been the subject of current investigation. This paper describes several experimental models used for *in vitro* and *in vivo* studies on the role of T-lymphocytes in the humoral immune response as well as the role of the thymus in the ontogeny of cell-mediated immunity. Although several types of inducers of gross thymic atrophy exist, the specific effect of each differs depending on the cell population affected. Nevertheless, these differences as well as the gradual induction of thymic atrophy at various times during the perinatal development of the host make these models more useful than those employing surgical means or animals with genetically determined absence of the thymus (nude mice).

BLOOD CLEARANCE PATTERNS IN MICE CHALLENGED WITH YEAST-LIKE AND PSEUDOHYPHAL FORMS OF CANDIDA ALBICANS. Z. A. Evans\*, E. Robinette, Jr.\* and D. N. Mardon. Dept. of Microbiology, Med. Coll. of Va., Richmond, Va. 23298

Following growth in a glucose-salts-biotin medium for 22 hours at 27°C, a virulent yeast-like strain of *C. albicans* and a pseudohyphal variant of low virulence were injected intravenously into separate groups of test mice. At the dose given, all animals receiving the yeast-like form died within 10 days after inoculation but none of the animals given the pseudohyphal form died.

Clearance of both forms from the blood was essentially complete within 3 hours. Yeast-like cells localized predominantly in the liver while pseudohyphal cells localized primarily in the lung. Relatively few cells of either form localized in the spleen or kidneys. However, between 18 hours and 6 days after injection with yeast-like cells, there were increased cell numbers in the kidneys. During this same period the number of cells in these organs did not increase when mice were challenged with the pseudohyphal form.

A corollary system using the yeast-like form and pseudohyphal form of the same virulent strain has been developed and will be tested in future studies.

ESTIMATION OF INITIATION BY RNA POLYMERASE. B. A. Fay\* and E. R. Stout. Dept. of Biology, Virginia Poly. Inst. & State Univ., Blacksburg, VA 24061.

Inhibitors of RNA polymerase function may affect the initiation of elongation phases of the reaction, or both. In order to unambiguously define the mode of action of such inhibitors, a rapid and convenient assay for initiation was developed. It consists of using [ $\gamma$ - $^{32}$ P]ATP as the labeled substrate for the reaction. Only the 5'-terminus of the RNA chain is labeled, as the 8' and  $\gamma$  phosphates are lost as inorganic pyrophosphate. Upon base hydrolysis, the adenosine residues at the 5'-end of the RNA are released as 3'-phosphoadenosine 5'-triphosphate - a tetraphosphate. Adenosine tetraphosphate was isolated from hydrolysis by descending chromatography on DEAE-paper in a 0.1 M LiCl<sub>2</sub>, 0.01 M HCl solvent system.

This assay has been used to investigate the site of inhibition of two *E. coli* RNA polymerase inhibitors: rifamycin SV, an initiation inhibitor, and streptolydigin, an elongation inhibitor. Rifamycin SV (0.8  $\mu$ g/ml) reduced the amount of adenosine tetraphosphate formed by 31% compared to control while streptolydigin (0.25  $\mu$ g/ml) stimulated initiation by 12%. Parallel experiments with *Zeamays* RNA polymerase II were conducted with  $\alpha$ -amanitin, an elongation inhibitor, and an endogenous inhibitor isolated from maize seedlings.  $\alpha$ -amanitin (0.3  $\mu$ g/ml) stimulated initiation by 18% over the control. Likewise, the maize inhibitor stimulated initiation, thereby establishing it as an elongation inhibitor.

MECHANISM OF Ga-67 UPTAKE IN HUMAN ABSCESSSES. M.J. Fraklin\* and R. B. Scott, Depts. of Radiology and Medicine, Med. Col. of Va., Richmond, Va. 23298.

We previously demonstrated that Ga-67 scanning accurately localized inflammatory abscesses in 29/32 patients. The purpose of this paper is to define the mechanism of Ga-67 uptake in these lesions.

Guinea pig bone marrow cells were incubated *in vitro* with Ga-67. The albumin density gradient fractions containing mature, phagocytic granulocytes readily accumulated Ga-67 ( $41.7 \times 10^3$  cpm/ $10^6$  cells), but Ga-67 was more avidly taken up by the immature, non-phagocytic granulocytes ( $139 \times 10^3$  cpm/ $10^6$  cells). *In vivo* studies of guinea pig marrow yielded similar results.

Abscess material was obtained at laparotomy from 3 patients with positive Ga-67 scans. The abscess wall had a 10-fold greater Ga-67 uptake than normal tissue. However, the inflammatory cells of the liquefied abscess cavity concentrated Ga-67 no more avidly than an equal population of peripheral Wbc's.

Conclusions: (1) Granulocytes and inflammatory cells concentrate Ga-67 *in vitro* and *in vivo*. (2) Ga-67 uptake however, is not solely dependent on phagocytic function. (3) The positive scan results from the presence of vast numbers of Ga-67 laden inflammatory cells in the abscess.

AIDED BY NIH GRANTS CA 08482 AND GM 19641

CORRELATION OF VIRULENCE OF STRAINS OF CANDIDA ALBICANS TO CHEMOTAXIS OF POLYMORPHONUCLEAR LEUKOCYTES. V. M. Fueston, III, P. B. Hamilton and B. A. Weeks. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va., and Dept. of Microbiology, North Carolina State University, Raleigh, N.C.

Blastospores and mycelial suspensions of virulent and avirulent isolates of *Candida albicans* were compared for their chemotactic effects on human leukocytes. The relative pathogenicity of *C. albicans* isolates was determined by their ability to produce neurological disturbances, mortality, and decreased growth rate in 2-week old chickens. Chemotaxis was assayed by placing the leukocytes and the material to be tested in individual compartments separated by a nucleopore filter. Activity was quantitated by counting the leukocytes that had migrated. Chemotactic activity was inversely related to strain virulence with blastospores; however, no particular relationship was seen with mycelia. Cell wall fractions of blastospores exhibited chemotactic activity similar to that shown by intact blastospores. Cytoplasmic fractions of blastospores exhibited decreased chemotactic activity. These results demonstrate that virulence of *C. albicans* and decreased chemotactic activity for human leukocytes are positively correlated.

STUDIES ON THE PATHOGENICITY OF CANDIDA ALBICANS IN YOUNG CHICKENS. P. B. Hamilton, H. R. Luster\* and B.A. Weeks. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. and Dept. of Microbiology, North Carolina State Univ., Raleigh, N.C.

Twenty strains of *Candida albicans* isolated from chickens, pigeons and humans were evaluated for virulence by both oral and intravenous inoculation. Orally inoculated birds showed milder infection than the birds inoculated by intravenous injection. Two groups of the orally inoculated birds exhibited reduced growth rates while sixteen groups of the birds inoculated intravenously exhibited reduced growth rates. Determination of excreta and crop numbers of *Candida albicans* and relative crop weights revealed that the infection from oral inoculation was mild. Birds inoculated by intravenous injection exhibited extreme growth depression, moderate mortality and neural disturbances.

QUALITATIVE AND QUANTITATIVE SHIFTS IN CELLULAR LIPID DURING INTRACYTOPLASMIC MEMBRANE FORMATION IN *GLUCONOBACTER OXYDANS*. D. L. Hefner\* and G. W. Claus. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

*G. oxydans* differentiates by forming intracytoplasmic membranes as cells enter the stationary growth phase, and the quantity of their internal membranes increases as cells are held in the stationary phase. In order to determine if this differentiation is accompanied by a detectable increase in cellular lipids, lyophilized cells were extracted for total lipid (free and bound), purified on Sephadex, and dried under  $N_2$  to a constant weight. Differentiated cells sampled 4, 8 and 16 hours after entrance into stationary phase contain 75, 71 and 125% more total lipid per cell than found in undifferentiated cells. After adjusting these quantitative measurements to account for an increase in length during stationary phase, differentiated cells still contain 40, 37 and 40% more lipid than can be attributed to an increase in size alone. Quantitative shifts in individual phospholipids and fatty acids are noted during the elaboration of intracytoplasmic membranes. We conclude that intracytoplasmic membrane formation in *G. oxydans* is accompanied by a net lipid synthesis as well as shifts in the proportions of individual lipids.

DISTRIBUTION OF HL-A ANTIGENS IN PRE-COLUMBIAN MUMMIES. A. A. Hossaini, M. J. Allison, and Ahmad Khori\*, M.D., Div. of Clinical Pathology, Med. Col. of Va., Richmond, Va. 23298

A modified lymphocytotoxicity technique was devised to study the distribution of 13 HL-A antigens in 58 Pre-Columbian mummies (Peruvian & Chilian). In these studies, the extracts from the muscles of these mummies were used in the inhibition tests.

Forty-three of the 58 mummies showed the presence of from one to three of the HL-A antigens. The remaining 15 mummies gave negative results with all 13 anti-HL-A sera. The distribution of the histocompatibility antigens studied was observed to be similar to that reported for present day American Indians. The technique used in these studies was found to be reproducible and dependable. It is hoped that this technique of HL-A typing of mummified tissues may provide an additional tool in the field of mummy anthropology. (Aided by National Geographic Society grant.)

Effects of Endotoxin on WI-38 Cells in Culture. Donna-Beth Howe, and S. G. Bradley, Dept. of Microbiology, Virginia Commonwealth University, Richmond, Va.

WI-38 is a human embryonic lung continuous cell line. In this study WI-38 cells were cultivated in Minimum Essential Medium with Earle's balanced salt solution, glutamine and 5% (v/v) fetal calf serum. Of sixteen  $^{14}C$  labeled precursors (0.05  $\mu$ Ci/ml) only adenine (53%), uridine (15%), and serine (12%) were substantially taken up in an 18 hour time period by WI-38 cells.  $^{14}C$ -Leucine was substantially taken up when the original medium lacked leucine. Only 7%  $^{14}C$ -thymidine (0.2  $\mu$ Ci/ml) was taken up in a 48 hour period. Added  $^{14}C$ -uridine was incorporated into RNA,  $^{14}C$ -leucine into protein,  $^{14}C$ -thymidine into DNA.  $^{14}C$ -Adenine was distributed in RNA (71%), the trichloroacetic acid-soluble pool (21%) and lipid (8%).  $^{14}C$ -serine was incorporated into protein (71%), lipid (22%) and RNA (10%). Bacterial endotoxin (100  $\mu$ g/ml) [*Escherichia coli* 0127: B8 Lipopolysaccharide, Difco] was added to confluent WI-38 cultures simultaneously with the labeled compounds. Uptake was monitored for a 6 hour period and showed that endotoxin neither inhibited nor stimulated uptake of adenine, leucine, serine, or uridine. Thymidine uptake over a 48 hour period was neither inhibited nor stimulated. Some changes were observed in the distribution of label in the macromolecular fractions for  $^{14}C$ -serine and  $^{14}C$ -thymidine in the presence of endotoxin.

PROTEIN-CALORIE MALNUTRITION AND THE CELLULAR IMMUNE RESPONSE IN NEWBORN GUINEA PIGS. B. Israel, M.R. Escobar, W. Dutz\* and M. Taylor\*. Dept. of Pathology, Med. Col. of Va., Virginia Commonwealth Univ., Richmond, Va. 23298

Guinea pigs were used as an animal model to study the effects of protein-calorie malnutrition (PCM) on the development of the cell-mediated immune system. Newborn animals were weaned at 48 hours and given a restricted diet for ten days followed by feeding *ad libitum*. Control animals were fed *ad libitum* from birth. Daily weights were recorded. Significant differences were observed only at 10 days.

At 6 weeks no significant difference was observed in the ability of lymphocytes from either group to respond to PHA or in the percentage of spontaneous rosette forming cells (RFC) in the thymus or lymph nodes of experimental as compared to control animals.

Both groups were sensitized to 2,4-DNCB at 4 weeks and challenged 14 days later. Of the 17 control animals tested, 94.1% were able to respond to a 0.1% solution of 2,4-DNCB as compared to only 38% of the experimental animals ( $p < 0.01$ ). All animals exhibited a normal inflammatory response to the sensitizing dose of 2,4-DNCB. When the negative experimental animals were re-challenged two weeks later, 5 out of 8 converted to positive. The ability to respond to 2,4-DNCB at 6 weeks of age did not correlate with either birth weight, change in weight during the period of restricted food intake, or body weight at the time of challenge.

ENHANCEMENT OF ENZYME ACTIVITY BY A SUPPRESSOR MUTATION IN *ESCHERICHIA COLI*. J. C. Leonard\* and R. M. Gibbs. Program in Human Genetics, Va. Commonwealth Univ., Richmond, Va. 23298

*araB14* is a nonsense (UAG) mutant located in the L-ribulose kinase structural gene of the L-*ara* biosynthetic operon of *E. coli*. The nonsense codon has two noted phenotypic effects. First, a functional kinase is not produced and second, a polar effect is exerted on L-*ara* biosynthetic isomerase, produced by the adjacent operator-distal structural gene. A partial revertant, designated *araB14R1*, was isolated from *araB14* and shown to be the result of a nonsense to missense mutation. *araB14R1* produces a functional kinase with 20% of the activity of the wild type kinase. In addition isomerase activity is increased to a level twice that found in the wild type. An extragenic suppressor (*SuB*) that is specific for the missense codon of *araB14R1* increases the kinase activity of *araB14R1* to 40% of the wild type level but does not affect the isomerase level. Electrophoretic comparisons of the partially purified wild type, *araB14R1*, and *araB14R1SuB* kinases suggest that the *SuB* locus causes replacement of the missense amino acid of *araB14R1* with a different missense amino acid resulting in a kinase with a higher level of activity. (Aided by NIH grant GM-11098).

ARACHNOIDAL REACTION DUE TO FREE-LIVING AMEBIC INFECTION. A. Julio Martinez\*, Juan Astruc\* and Mario Escobar. Departments of Pathology and Anatomy, Med. Coll. of Va., Richmond, Va. 23298

Arachnoid phagocytic capability can be elicited following infection by pathogenic ameba *Naegleria fowleri* strains. Mice were intranasally inoculated with CJ strain and became moribund 5-7 days after inoculation with  $5-10 \times 10^3$  organisms/0.1ml. The pia-arachnoid cells were observed to actively phagocytose and destroy some of the invading protozoa in the subarachnoid space.

The neuropil revealed extensive necrotizing hemorrhagic lesions during the course of the infection, mainly on the base of the brain, on the anterior aspects of the cerebrum and on the cerebellum.

These experiments indicate that transformed arachnoid cells as well as migratory macrophages from the circulation do participate in the host defense mechanism as active phagocytes. In addition, it is suggested that an allergic type of inflammatory response is elicited in the earliest phases of the infection by protozoa and disintegrating neural tissue. An antigen-antibody interaction is initiated, thus forming the characteristic histopathological picture of primary amebic meningoencephalitis.

LABORATORY DIAGNOSIS OF PNEUMOCYSTIS CARINII PNEUMONIA. E. Kohout. Veterans Administration Hospital and Med. Coll. of Va., Virginia Commonwealth Univ., Richmond, Va. 23298

The difficulties to diagnose *Pneumocystis carinii* pneumonia during the life of the patient are closely related to the pathological development. In the early and easily curable stages of the disease, the infiltrate is localized in the posterior subpleural alveoli. Specimen can best be obtained by transthoracic needle aspiration or deep bronchoscopy with alveolar biopsy. Tracheal smears become positive late and additionally are not diagnostic for the disease due to carrier states. We found Giemsa smear imprints superior to smear preparations by the silver stain methods since the diagnostic form of the organism can be better recognized by the former. The complement fixation test of Barta and Vivell were useful only in infantile pneumocystosis in which an IgG antibody response developed about three to six weeks after the disease. The fluorescent antibody tests of Meuwissen and of Kagan and Norman are unfortunately nonspecific despite their higher sensitivity. Contacts can be easily detected. The recent report of artificial growth of the organism by Hughes promises better fluorescent antigens in the near future with which the organisms can be more readily detected. Other methods of diagnosis have not been promising.

STUDIES ON A MUCOID CLINICAL ISOLATE OF ENTEROBACTER CLOACAE. F.L. Macrina\*, M. Tipple, R.J. Dum\* and R.B. Finley\*. Depts. of Microbiol. and Med. and Div. of Infect. Diseases, Med. Col. Va., Va. Commonwealth Univ., Richmond, Va. 23298.

A strain of *Enterobacter cloacae* which produces copious amounts of exopolysaccharide material has been isolated from the blood of a patient with septicemia. During growth in broth culture this mucoid strain gives rise to cells which are deficient in exopolysaccharide synthesis. Such cells appear as non-mucoid colonies on agar plates and are never seen to revert back to the mucoid state. Segregation of this mucoid phenotype led us to believe that exopolysaccharide synthesis was controlled by an extrachromosomal element (plasmid). However, growth of the mucoid strain in the presence of known plasmid curing agents failed to enhance the frequency of occurrence of non-mucoid clones. Furthermore, both the mucoid and the non-mucoid strains were found to contain identical species of plasmid DNA. The function of this plasmid DNA remains unclear. The mucoid strain did not act as a conjugal donor in crosses where carbenicillin resistance or exopolysaccharide synthesis transfer was measured. R plasmid transfer from *E. coli* to mucoid *E. cloacae* was substantially less efficient than from *E. coli* to non-mucoid *E. cloacae*. (Supported in part by a grant from the Cystic Fibrosis Foundation)

EVALUATION OF CULTURES OF *N. GONORRHOEA* FOR THE PRESENCE OF L-FORMS AND MYCOPLASMA. P. A. Mickelsen\* and H. P. Dalton. Dept. of Pathology, Med. Col. of Va., Richmond, Va. 23298.

Thirteen (13) cultures of *N. gonorrhoeae* were examined simultaneously for the presence of mycoplasma and gonococcal L-forms. *M. hominis* was found in 11 (84.6%) of these cultures and could grow alone or in the presence of gonococci on chocolate agar. However, *M. hominis* could not be maintained in cultures of *N. gonorrhoeae* on a medium commonly used for gonococcal colony typing. *M. hominis* will also grow on media used for the cultivation of gonococcal L-forms and can be differentiated from L-forms by use of the oxidase test.

L-forms were produced by 11 (84.6%) of the isolates of *N. gonorrhoeae*. Spontaneous conversion to the L-form occurred in 9 of the 11 strains examined.

SKIN LESIONS OF CYTOMEGALOVIRUS INFECTION: AN ATYPICAL MANIFESTATION. N. Minars\*, J. F. Silverman\*, M. R. Escobar and Y. S. Fu\*, Depts. of Dermatology and Pathology, Med. Coll. of Va., Richmond, Va. 23298

The symptoms of Cytomegalic Inclusion Disease (CID) in the adult are often nonspecific and vary with the organ involved. In localized forms the lungs and gastrointestinal tract are commonly affected whereas in the disseminated form almost all tissues can be infected. However, histological evidence on the direct association of skin lesions with cytomegalovirus (CMV) has not been well documented.

In this work we attempted to demonstrate the presence of CMV-induced vasculitis leading to non-healing cutaneous ulcers in a 24-year old white female renal transplant patient. Histological examination of punch biopsies from ulcers on the right leg and right upper arm revealed involvement of the small dermal vessels with narrowing of their lumen. Typical CMV inclusions were present in the characteristically enlarged endothelial and perithelial cells of the small arterioles, venules and capillaries. Occasional cells had circumscribed granular pale eosinophilic intracytoplasmic inclusions. There was a severe perivascular and interstitial infiltrate composed of polymorphonuclear neutrophils, histiocytes and lymphocytes.

Indirect immunofluorescent staining of tissue sections from various organs showed the presence of HB<sub>e</sub> and CMV antigens. Electron micrographs revealed herpes-like viral particles in these tissues.

HOST CELL RESPONSE TO INFECTION WITH BOVINE PARVOVIRUS.

D. S. Parris\* and R. C. Bates. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Events occurring during the replication of bovine parvovirus (BPV) were studied in bovine fetal spleen (BFS) cells synchronized at the G<sub>1</sub>/S border with 2 mM hydroxyurea (HU). Although no DNA synthesis was occurring after 32 hr of exposure to HU, BFS cells began to rapidly synthesize DNA immediately after HU removal, and within 1 h, 80-85% of the cells were in S phase as determined by autoradiography. Viral specific antigens, hemagglutinating activity, and infectious progeny virus appeared in a synchronous manner rapidly in synchronized BFS cells infected at the beginning of S phase than in infected asynchronous cell cultures.

Host cell DNA synthesis was not reduced when cells were infected with BPV at the beginning of S phase. However, beginning at 8 h postinfection (PI), the rates of total RNA and protein synthesis began to decrease below those values observed in mock-infected cells. At that time, BPV DNA began to appear in infected cells as did infectious progeny virus. By 14 h PI when BPV DNA synthesis was maximum, the rates of total RNA and protein synthesis were reduced to 43% and 26% of the control levels. These results indicate that BPV is replicated optimally and synchronously in S phase BFS cells. Furthermore, infection of cells with BPV does not inhibit the synthesis of cellular macromolecules until after the cells are fully committed to virus production.

Effects of Antitubercular Drugs on *Mycobacterium farcinicum*. Linda A. Talley, and S. G. Bradley, Dept. of Microbiology, Virginia Commonwealth University, Richmond, Va.

The *in vitro* susceptibility of *Mycobacterium farcinicum* to ten antitubercular drugs has been assessed. The antitubercular drugs selected for this study were cycloserine, ethambutol, ethionamide, isoniazid, kanamycin, para-aminosalicylic acid, pyrazinamide, rifampin, streptomycin and viomycin. The capability of the capsule 3'-5'-cyclic monophosphate acid, dimethyl sulfoxide (DMSO) or ethylenediaminetetraacetic acid (EDTA) to modify the *in vitro* response of *M. farcinicum* to drugs was measured. DMSO at concentrations of 2 to 3% inhibited growth of *M. farcinicum*, as did 10<sup>-4</sup> to 10<sup>-3</sup> M EDTA. Cyclic adenosine monophosphate at concentrations of 5X10<sup>-4</sup> to 5X10<sup>-3</sup> M did not markedly affect growth. In general, the pattern of susceptibility of *M. farcinicum* was not significantly altered by subinhibitory concentrations of DMSO, EDTA or cyclic adenosine monophosphate. Some drug resistant variants of *M. farcinicum* possessed increased resistance to DMSO. Moreover, variants selected for resistance to one antitubercular drug sometimes developed concurrently increased susceptibility to another drug.

RELATIONSHIP BETWEEN PHAGOCYTOSIS AND THE PRODUCTION OF LEUKOCYTIC PYROGEN. R. H. Mitchell, F. Goodale and G. W. Gander. Dept. of Pathology, Med. Coll. of Va., Richmond, Va. 23298.

The release of an endogenous pyrogen from cells of the host in response to the appropriate stimulus has been implicated in experimental models of the pathogenesis of fever. This material is known to be released from rabbit polymorphonuclear leukocytes in response to a number of stimuli including bacteria, endotoxin and virus.

Recent evidence indicates the possibility of two separate pyrogen production responses by the host depending on the stimulus. One response is made by the circulating polymorphonuclear leukocytes, the other response is made by the phagocytic cells of the fixed reticuloendothelial system. In some cases both responses may occur to the same stimulus.

The production of endogenous pyrogen *in vitro* by rabbit buffy coat cells in response to stimulus by either endotoxin or by phagocytosis of endotoxin-free, uniform latex particles has been studied. The use of cytochalasin B, an inhibitor of phagocytosis, was made in order to investigate the role of rabbit buffy coat cells in the production of endogenous pyrogen. The evidence suggests a direct relationship between the amount of phagocytosis of latex particles and the amount of endogenous pyrogen produced.

Aided by NIH Grant AI10801

Endotoxic Activity of Protein-Lipid Complexes. Mark Smith and S. G. Bradley, Dept. of Microbiology, Virginia Commonwealth University, Richmond, Va.

Endotoxin is a component of the outer cell wall of the enteric bacteria. Chemically endotoxin is a lipopolysaccharide (LPS) composed of a hydrophilic portion and a hydrophobic portion called lipid A. Free lipid A can be prepared from LPS by mild acid hydrolysis. Free lipid A is devoid of biological activity. Lipid A-protein complexes possess many of the attributes of LPS, e.g. they synergistically kill mice in combination with antitumor drugs such as methyramycin. The capability of lipid-protein complexes to provoke granulocytosis and to kill mice rendered hyperreactive to LPS by methyramycin has been assessed. Of the 17 complexes tested, only 6 possessed presumptive endotoxic activity. Of the 7 complexes of lipids with bovine serum albumin (BSA), only myristic acid-BSA possessed endotoxic activity. Of the 10 complexes of lipids with concanavalin A (Con A), 5 complexes possessed endotoxic activity. Of these 5 complexes, only myristic acid-Con A and dimethyl myristamide-Con A consistently killed mice. Prior treatment of mice with myristic acid-protein complexes rendered the animals resistant to a dose of LPS that is lethal for untreated animals. Prior treatment of mice with LPS rendered them resistant to a combination of methyramycin and a complex of myristic acid-BSA or dimethyl myristamide-Con A that is lethal for untreated animals. Lipid-protein complexes, like LPS, provoked granulocytosis. These data indicate that a fatty acid is the principal functional component of the endotoxin toxophore.

RESPONSES OF *BACILLUS THURINGIENSIS* TO BACTERIOPHAGE CP-51. R. L. Van Tassel\* and A. A. Yousten\*. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Eight varieties (serotypes) of *Bacillus thuringiensis* were tested for their response to bacteriophage CP-51, a generalized transducing phage of *Bacillus cereus*. All eight varieties supported efficient replication of the phage, whereas many other species of *Bacillus* failed to act as host. Although the free phage is highly susceptible to cold storage, phage genome packed within spores of *Bacillus thuringiensis* and *Bacillus cereus* prove to remain stable for over nine and thirteen months respectively, at 4°C and 17°C. A variety of plaque types were observed which appear to be dictated, at least in part, by the particular strain of *B. thuringiensis* used as lawn host for phage growth. These preliminary studies help form a basis for the future attempts at establishing transduction in *B. thuringiensis*.

THE EFFECT OF PROTEIN-CALORIE MALNUTRITION ON PLASMA CYCLIC AMP LEVELS IN AN ANIMAL MODEL. B.A. Weeks, M.R. Escobar and W. Dutz. Old Dominion University, Norfolk, and Virginia Commonwealth University, Richmond, Va.

Cyclic 3',5'-adenosine monophosphate (cAMP) has been implicated in the general control of cell surface properties and the immune response. Protein-calorie malnutrition has been found to depress cell-mediated immunity in animal models as well as in humans. These findings led us to investigate the differences among male and female adult guinea pigs and newborn guinea pigs grouped according to dietary intake. For that purpose, replicate samples of plasma were analyzed by the Gilman technique indicating that cAMP levels of normal adult male and female guinea pigs corresponded to those found in humans (11.2-24.8 picomoles/ml.). However, normal neonatal guinea pigs fed ad lib had a slightly lower range (9.2-9.7 picomoles/ml.). cAMP in suckling guinea pigs ranged from 5.7 to 9.5 picomoles/ml. whereas newborn guinea pigs starved for 10 days after birth had 6 to 8-fold lower values (0.5 to 2.4 picomoles/ml.). These studies demonstrate that plasma cAMP in malnourished guinea pigs was reduced significantly when compared to well-nourished animals. These results suggest that the regulatory processes altered during malnutrition may be related to inability to maintain sufficient plasma cAMP concentration.

RELATION OF INTRACITOPLASMIC MEMBRANE DEVELOPMENT IN *GLUCONOBACTER* TO RATES OF SORBITOL OXIDATION. Stephen A. White\* and G. W. Claus. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

*Glucanobacter oxydans* subsp. *suboxydans* characteristically performs single-step polyol oxidations with membrane-bound dehydrogenases. We recently found early stationary phase cells to contain quantities of intracytoplasmic membranes (ICM) not present in exponentially growing cells. The effect of this ICM accumulation on the rate of sorbitol oxidation was examined. Cultures were grown in a buffered, complex medium containing 5.0% sorbitol. Exponentially growing cells, devoid of ICM, were harvested at 0.3 O.D.<sub>620</sub> and cells containing ICM were harvested one hour after reaching maximum turbidity (1.5 O.D.<sub>620</sub>). Resting cell suspensions were subjected to a variety of environmental conditions, and the rates of oxygen uptake were assayed by differential respirometry. Under certain conditions cells containing ICM, oxidized sorbitol 100% more rapidly than cells lacking ICM. Both cell types were found to maximally oxidize sorbitol at a concentration of 5% (w/v), pH 5.0 and 38°C. Under these optimal conditions, cells containing ICM exhibit an average Q<sub>0</sub> of 3,100, whereas cells devoid of ICM demonstrate an average Q<sub>0</sub> of 2,500. At the present time, the reason for ICM development and heightened oxidative activity during the early stationary phase is not known.

OXYGEN METABOLISM OF CATALASE-NEGATIVE AND CATALASE-POSITIVE STRAINS OF *LACTOBACILLUS PLANTARUM*. A. A. Yousten\*, J. L. Johnson\*, and M. Salin\*. Dept. of Biology and Anaerobe Lab., Va. Polytechnic Inst., Blacksburg, Va. 24061 and Dept. of Medicine, Duke Univ. Med. Ctr., Durham, N. C. 27710

Two catalase-negative strains of *Lactobacillus plantarum* and a strain producing the atypical, non-heme catalase were studied to determine if the ability to produce the atypical catalase conferred any growth advantage upon the producing strain. Both catalase-negative strains grew more rapidly than the catalase-positive strain under aerobic or anaerobic conditions in a glucose-containing, complex medium. Upon exhaustion of glucose from the medium, all three strains continued growth under aerobic but not under anaerobic conditions. The continued aerobic growth was accompanied by production of acetic acid in addition to the lactic acid produced during growth on glucose. Oxygen was taken up by exponential phase cell suspensions grown on glucose when glucose or glycerol were used as substrates. Cells harvested from glucose-exhausted medium oxidized glucose, glycerol, and pyruvate. Oxygen utilization by a catalase-negative strain increased as did the specific activity of NADH peroxidase during late growth in glucose exhausted medium. The catalase-positive strain and the catalase-negative strain tested both possessed low but readily detectable levels of superoxide dismutase throughout growth. The growth response is discussed in terms of the presence of enzymes which would allow cells to remove damaging reduction products of O<sub>2</sub>.



## Abstracts of Papers

# Section of Psychology

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

**INTERACTIVE EFFECTS OF MEDIA, COMMUNICATOR AND POSITION ON ATTITUDE CHANGE.** V.A. Andreoli\*, Dept. of Psychology, Univ. of N.C. 27514, and S. Worchel\*, Dept. of Psychology, Univ. of Va., Charlottesville, Va. 22901

This study examined the effects of media, communicator and message content on the persuasiveness of a communication. Subjects received a television, radio or written presentation which either agreed or disagreed with the subject's initial position. The communicator was either a political candidate, a congressman, an excongressman or a newscaster. The results indicated that the newscaster and excongressman were considered most trustworthy, the congressman next most trustworthy and the candidate least trustworthy. Although there was no main effect for media, it did interact with the source and position variables. When the communication opposed the audience's position, television was the most effective medium for the newscaster and excongressman but least effective for the candidate. There was no media effect when the communicator agreed with the audience.

**THE EFFECTS OF ONE- VS. TWO-STAGE LESIONS OF THE HIPPOCAMPUS ON DRL-20 BEHAVIOR.** W.M. Bannister\* and L.E. Jarrard. Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

Ten albino rats with one- and two-stage lesions of the hippocampus were tested on a DRL-20 task. Subjects were placed in one of five groups, these being a control, two unilateral groups, a one-stage and two-stage group. The results suggested that animals which received bilateral damage to the hippocampus in two separate operations did not differ significantly from those that received bilateral damage in one operation. Both groups showed a sharp deficit on the DRL-20 task, thus demonstrating that such destruction cannot be compensated for by other parts of the brain.

**PERCEPTUAL IMPAIRMENT IN PSYCHIATRIC COMPLAINTS.** S. Berent. Perceptual Studies Lab., Dept. of Psychiatry, Univ. of Va. Med. Ctr., Charlottesville, Va. 22901

Recently admitted female psychiatric inpatients were given the rod-and-frame task and the Minnesota Multiphasic Personality Inventory (MMPI). All patients with an admission diagnosis of schizophrenia, organicity, or a reported history of alcoholism or electroconvulsive therapy were excluded from the study. Personality disturbance, as measured by the MMPI, for the remaining 75 patients, was found to be significantly less severe for extremely high-error (extremely field-dependent) rod-and-frame performers than for other patients in the sample. Hospital records and performance on self-rating scales revealed, however, that these patients with a high rate of error on rod-and-frame performance were subjectively as uncomfortable and as difficult to treat as the others tested. Results are discussed in terms of the possible contribution of perceptual impairment to the psychological complaints of these individuals.

Findings are related to earlier work in our laboratory which has shown correspondence between extreme field dependence and impaired performance on various tasks mediated by the dominant (left in right-handed persons) cerebral hemisphere. The possibility that the complaints that led to psychiatric hospitalization for the individuals under study might reflect underlying neurological disorder is explored. (Aided by NSF Grant 4276).

**THE INTERDEPENDENCE OF COGNITIVE AND SENSORY MOTOR ABILITIES IN THE DEVELOPMENT OF NORMAL AND BRAIN DAMAGED CHILDREN.** T. J. Boll\*, Dept. of Psychiatry and Pediatrics, Univ. of Va. Med. Sch., Charlottesville, Va. 22901

The purpose of this study was to investigate the ordering influence of tactile-perceptual abilities on a broad range of basic human adaptive tasks in children.

Hebb postulated that sensory functions were essentially uncorrelated with higher level psychological functions. In this investigation, a population of normal children was compared with an equal population of children with firm evidence of cerebral impairment.

The results of this study demonstrate the relationship between lower level sensory perceptual functions and higher psychological abilities. Brain damaged children with good tactile-perceptual functions performed better in a cognitive sense than did brain damaged children with poor tactile-perceptual functions. Normal children with good tactile-perceptual functions performed better than did normal children with poor tactile-perceptual functions. Groups formed on the basis of good and poor tactile-perceptual functions differed about as greatly on measures of cognitive ability as did groups formed on the basis of presence or absence of brain damage. Children with brain damage, but with intact tactile-perceptual functions, were not significantly different than children with normal brain functions who had difficulty on measures of tactile-perceptual ability.

THE EFFECT OF WORD LENGTH ON RECOGNITION THRESHOLDS. D. E. Doggett\*. Dept. of Psychology, Univ. of Va., Charlottesville, Va. 22901

Two studies were done to re-assess the influence of word length on tachistoscopic recognition thresholds. In the first, length varied from three to eleven letters while word frequency varied over three levels. In contrast with other studies, the main effect of length and the length by frequency interaction were not significant. The second study used only low frequency words with length varied over four levels. Again, no statistically significant effect of length was found.

The analyses of other investigators who report significant length and length by frequency interaction exemplify the "language-as-fixed-effect fallacy" reviewed by Clark (1973). In the present studies, word lists are treated as random effects in the analysis of variance. These results suggest a two-process theory of the effect of length: word length influences recognition thresholds only if the words are unfamiliar. Familiar words show no length effect.

THE ROLE OF PERCEPTUAL CUES IN CONSERVATION TASKS WITH MATURE SUBJECTS. David M. Gilfoyle\*. Department of Psychology, College of William & Mary, Williamsburg, Va. 23185

Recent research has indicated that there is a decrement in ability to conserve on standard Piagetian conservation tasks in old age. Subjects ranging in age from 65-92 years were tested on a standard conservation of liquid task. A screening procedure was incorporated into the experimental design in an attempt to enable any "non-conservers" to be able to conserve by overcoming any misleading perceptual cues. However, the effectiveness of this screening procedure was never tested as the ability to conserve held up extremely well with age. All subjects were successful conservers on both pretest and posttest. Such results indicate no theoretically meaningful changes in cognitive abilities in the aged.

A STUDY OF MOTIVATION AND ATTITUDES OF POLICE OFFICERS IN THE WASHINGTON, D.C. AREA. S. Heyka\*. Dept. of Psychology, Randolph-Nacon Woman's College, Lynchburg, Va. 22504

The attitudes of police officers toward their job and related factors were studied in the Washington, D. C. area. A questionnaire was distributed to 219 members of the United States Park Police (USPP) and the Metropolitan Police Dept. at random. Their stated motivations (for joining the force and for remaining on the force) were broken down into three categories: Social, Personal, Economic. Similar questionnaires were distributed to 155 non-law enforcement professional people in Lynchburg, Va. Their opinions regarding the motivation of police officers were broken down into the same three categories. A personal interview was conducted with 49 members of the USPP which covered areas of concern based on the first survey. Both questionnaires were designed to explore areas which could be used to formulate a standardized test of police attitudes for use in further research in this area.

COMMUNITY OF INTEREST: A STUDY OF EVENING COLLEGE STUDENT. R. G. Eppes\*. Evening College, Va. Commonwealth Univ., Richmond, Va. 23284

A stratified sample of 9808 students attending Virginia Commonwealth University evening classes was queried as to attitudes and satisfaction with classes composed of younger full-time day students and older working students from the community: 1546 day students were given a questionnaire and 1537 evening students. The returns were: 891 day surveys and 950 evening.

The student responses were favorable to mixing ages in the classroom: 86.1% of the day students preferred a class with both day and evening students; 77.4% of the evening students preferred the mixed classes.

The 483 adjunct and full-time faculty teaching evening classes were queried as to perception of the "mixed" classes. The percentage of return was 55%. Perceptions were generally favorable with only 19 full-time faculty indicating preferences for teaching a class for day students only.

SENTENCE COMPLETION AND SENTENCE RECOGNITION AS A FUNCTION OF CATEGORICAL PRIMING. D.W. Heckenbach\* and G.M. Croghan\*. Dept. of Psychology, Washington & Lee, Lexington, Va. 24450

Bartlett's theory of memory was tested with a sentence completion task in which sets of answers either did or did not come from the same category. Bartlett asserts we retain schemata; therefore, we should be able to complete sets of sentences more rapidly when the answers are related than when the answers are not related. Completing sets of related sentences should also increase the salience of particular schemata. To test these ideas, subjects received 10 lists of 10 incomplete sentences which they were to complete as quickly as possible with the first word that came to mind. For five lists appropriate completions came from the same category, while for the rest the completions came from different categories. After the last list, a recognition test was given that included both "old" and "new" sentences. More sentences from categorized lists were completed in the allotted time than were sentences from noncategorized lists. More false positive responses occurred during recognition to new sentences that contained completions from the same categories used in categorized lists than occurred to new sentences that contained words from the same categories used in noncategorized lists. Responding within a category facilitates the speed with which a sentence can be completed by activation of schemata. Categorical responding by activating schemata enhances the salience of a category and increases false recognition.

A COMMUNITY-INTEGRATED, BEHAVIOR MODIFICATION APPROACH TO FACILITATING PAPER RECYCLING. Richard E. Ingram\* and E. Scott Geller. Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

A behavior modification approach was utilized to affect the return of recyclable paper in college dormitories. Additionally, the study investigated the feasibility of integrating the community as a whole to aid in ecological rebalance.

The experimental design consisted of four conditions: 1) Flier Prompt Condition, 2) Verbal Prompt Condition, 3) Raffle Condition, and 4) Removal Condition.

Various portions of the community participated in the paper drive. A college recycling organization invested its time and effort in promoting the campaign. Undergraduates at the university manned the collection sites. Community merchants donated prizes to be used in the raffle. Local newspapers provided free advertisement and photos not only of the paper drive itself but of the winners of the raffle prizes and of the merchants donating the prizes.

Results indicate that the Raffle Condition was maximally effective. The data suggest that behavior modification approaches to facilitating paper recycling may be desirable. The results are discussed with reference to a promising conclusion-- that a workable, self-sustaining, economical community-based recycling program is feasible.

THE EFFECTS OF FAILURE ON SUBSEQUENT PERFORMANCE ON A SIMILAR TASK. R.A. Johnston and L.G. McCauley, College of William and Mary

In order to test the hypothesis that failure instructions function to increase D in the Hull-Spence system, Ss selected from the extremes of the distribution of A-scale scores were given failure instructions following a task unrelated to two paired-associates verbal learning criterion tasks. Failed Ss showed no decrement on the non-competitive list and performed better than the LA control group at all points on the learning scores. On the competitive list HA failed Ss showed a performance decrement but LA failed Ss performed better than LA non-failed Ss.

CONCEPTUAL STYLE AND CLASSROOM BEHAVIOR OF YOUNG PSYCHIATRIC PATIENTS. L.B. Keller\*, Dept. of Psychology, College of William and Mary, Williamsburg, Va. 23185.

The Brief Conceptual Style Test was administered to 19 hospitalized children who carried a diagnosis of psychosis, organic brain syndrome, or adjustment reaction. Analytic and relational responses were tabulated. An analytic response is one in which visual stimuli are grouped on the basis of similarity of stimulus elements. A relational response is one in which the grouping of the stimuli is based on a functional relationship between the stimuli. The number of analytic and relational responses was compared with teacher ratings of each child's hyperkinetic behavior, adaptiveness to learning, impulsivity, withdrawal, and task involvement. No systematic relationship was found between these ratings and conceptual responses. Generally the number of analytic responses produced increased and the number of relational responses decreased with age although the effect was smaller than that which has been reported for public school children. The psychotic children produced fewer relational responses than the non-psychotic children; this suggests that differences in conceptual style between non-psychotics and psychotics may result from the latter's inability to see functional relationships between visual stimuli.

THE EFFECTS OF S+ AND S- ON OBSERVING BEHAVIOR IN A SIMULTANEOUS DISCRIMINATION. H. S. Lawrence\*, Dept. of Psychology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Eighteen pigeons were run on a discrete trial, simultaneous form discrimination in a three key chamber. At the beginning of a trial, each observing response on the red center key produced only S+ (the correct choice), only S- (the incorrect choice), or both S+ and S- on the side keys for 0.5 seconds. Group I received the S+ or S- trials while Group II received all three types of trials. In both groups the pigeons made more observing responses before than after reaching the learning criterion. Group I made fewer observing responses and more errors on S+ trials than on S- trials before and after learning. There were no significant differences in observing responses or errors on the three types of trials in Group II before learning. In the ten sessions after learning, Group II made fewer observing responses and more errors on S+ trials than on S- trials or on S+ and S- trials.

According to the secondary reinforcement hypothesis, observing responses are maintained by stimuli associated with primary reinforcement. An alternate explanation, the information hypothesis, which predicts that both S+ and S- maintain observing behavior by the reduction of uncertainty, is supported by the present data.

INFLUENCES OF CONTOUR AND FIGURAL COMPLEXITIES ON THE VISUAL PERCEPTION OF FORM. Henry G. Lühring, III\*, C. J. Adkins, Jr.\*, and Earl A. Alluisi\*. Performance Assessment Lab., Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23508

In a further exploration of the information-deductive approach to the study of form perception, 20 adult subjects responded in a paper-and-pencil figure-cancellation task to constrained metric histograms of different contour and figural complexities. Three levels of figural complexity (4x4, 6x6, and 8x8 figures) were combined factorially with two levels of contour complexity or irregularity (low and high extremes), with equal figure-cell sizes.

Perceptual performance was found to decrease with increasing figural complexity; the mean number of correct cancellations per minute was 15.9, 14.1, and 12.6 for 4x4 through 8x8 figures, respectively. Likewise, performance with the higher contour complexity (13.0) was worse than with the lower (15.4). Both sets of differences were statistically significant beyond the .001 level of confidence. There was no indication of an interaction between figural and contour complexity.

(Supported in part by the Old Dominion Univ. Res. Fnds.)

REHEARSAL PROCESSES AND THE SPACING EFFECT. L.F. Lyles\*, J.A. Wood\*, and D.G. Elmes. Department of Psychology, Washington and Lee University, Lexington, VA 24450

The role of rehearsal processes in the spacing effect was examined by varying the rehearsal instructions and the type of rehearsal demanded by the mode of presentation. Sixty-four college-student subjects saw and attempted to free recall a long list of common English nouns in a 2 x 2 x 6 factorial design that included rote and elaborative rehearsal instructions; simultaneous and successive modes of list presentation; and six spacing intervals between repetitions of the to-be-remembered words (spacing intervals of 0, 2, 4, 8, 20, and 40 words). The free recall lists were comprised of 48 different nouns with four nouns repeated at each of the six spacing intervals. Elaborative rehearsal yielded better recall than did rote rehearsal, and recall increased as spacing interval increased for both types of rehearsal instruction. A large spacing effect was obtained with successive presentation, but there was a negligible spacing effect with simultaneous presentation. It appears that both the type of rehearsal and the nature of the rehearsal groups are important determiners of retention.

(Aided by a Robert E. Lee Research Grant)

DISCRIMINANT FUNCTION ANALYSES OF CLINICALLY DETERMINED CATEGORIES OF LEARNING DISABILITY. B.L. Mallinger\*, Dept. of Psychology, Radford Col., Radford, Va. 24142, and S.W. Owen\*, Bureau of Educational Res., Univ. of Conn., Storrs, Conn. 06268

There is a need to determine the extent to which the "Background Interference Procedure" (BIP) as an adjunct to the Bender-Gestalt can account for criterion variance beyond that level predicted by an optimal predictor battery. Discriminant functions empirically classified subjects into clinical categories of learning disability. A reduced battery of intellectual and visual-motor predictors generated two significant functions, accounting for 91% of the variance. The first dimension reflected overall intellectual functioning; the second, psychomotor skills. Empirical classification accurately categorized 71% of all subjects across five criterion groups. The functions efficiently separated the criteria, but the six BIP predictor variables did not improve prediction. Implications include using the BIP for early screening of learning disabilities, and employing discriminant functions for data reduction and construct validation of teachers' and judges' ratings.

THE EFFECTS OF TASTE ON LIQUID CONSUMPTION IN OVERWEIGHT AND NORMAL WEIGHT CHILDREN. J. J. Montuori\*, and H. T. Mullis\*. Psychology Department, Radford College, Radford, Virginia. 24142

Previous research suggests that overweight organisms ingest more good-tasting and less poor-tasting food and liquid than normal and underweight organisms. The present experiment is a pilot study to determine the relationship of taste weight, and liquid consumption. Sweetened and unsweetened Kool-Aid were given to preschool children of varying weight. Analysis of the data indicated that there were no differences in liquid consumption between light and heavy children, which did not support previous research findings. Relevant variables for future research were discussed.

INDIVIDUAL DIFFERENCES IN SIMPLE REPETITIVE TASKS UNDER DIFFERENT TYPES OF RESPONSE RESTRICTION AND FEEDBACK. J. P. B. O'Brien. Human Factors Psychology, Catholic Univ. of America and Tidewater Community College, Va. Beach, Va. 23456

A 3x3x3 factorial design, with 6 different Ss in each condition, was used to evaluate the effects of 3 conditions of feedback (zero extrinsic, low extrinsic, and high extrinsic), 3 conditions of response pattern restriction (no restriction dictated, restriction to three patterns, restriction to one pattern), and 3 levels of repetitive-figure manipulation diversity determined by scores on Torrance Tests of Creative Thinking, Form A, Activity III: repetitive parallel lines. The experimental task was to turn 9 circularly arranged knobs repetitively in a white visual, broadband audio environment over 3 6-minute periods separated by rest pauses. Performance, gross motor activity, error rates, and subjective impressions of arousal, alertness, boredom and performance adequacy are dependent variables.

This research is in the initial stages of data analyses. Performance on three-dimensional repetitive tasks appears to be unpredictable from two-dimensional tasks. Given the opportunity to vary response patterns, Ss will do so. S-induced variety is directly related to error factors.

EFFECTS OF ORBITAL AND MEDIAL PREFRONTAL LESIONS ON SHUTTLE-BOX AVOIDANCE PERFORMANCE IN THE RAT. M.S. Reifslager\*, C.J. Patton\*, and D.T. Anderson\*. (Sponsored by L.E. Jarrard) Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450

Recent evidence has indicated that the dorsomedial thalamic nucleus projects to two structurally discrete frontal cortical subfields. Further, these subfields have been shown to differ in terms of function (dissociable regarding general and specific activity, eating and hoarding behavior, and specific aggressive behaviors).

The current study was designed to test dissociability of the subfields with respect to active avoidance learning. Fourteen male albino rats were divided into 4 groups: operated and unoperated control groups of 3 rats each, and medial and orbital lesioned experimental groups of 4 rats each. Rats were tested in a two-way shuttle box task for 30 trials on each of 2 consecutive days, with an ITI of 2 minutes prior to each of the two test sessions. Results of the experiment will be discussed in light of recent research findings.

VIRGINIANS' ATTITUDES TOWARDS AND KNOWLEDGE ABOUT PERSONS WITH A DEVELOPMENTAL DISABILITY. F.B. Howe, Randolph-Macon Women's College, Lynchburg, Va. 24504, T.L. Ware\*, Developmental Disabilities Planning and Advisory Council, Richmond, Va. 23219, and S.G. Castle\*, Univ. of Md., Balto.

1,548 Va. residents were interviewed in order to determine their attitudes towards and knowledge about epilepsy, cerebral palsy, mental retardation, and mental illness. Information was also gathered on interviewee characteristics such as race, family income, age, and education. Only minor discrepancies were observed when the sample was compared with the 1970 U.S. Census data for Va. Therefore, it was concluded that the sample was representative of the residents of the state as a whole, and that interviewee responses to the attitude and knowledge questions would also be representative of Virginians as a whole.

The overall conclusion that appears to be warranted by the data is that, by and large, residents of the Commonwealth have positive attitudes towards persons with a developmental disability such as epilepsy and cerebral palsy, but that the situation is considerably less positive when it comes to persons who are mentally retarded or mentally ill.

CONCRETENESS EFFECTS ON RECOGNITION MEMORY DURING INTENTIONAL FORGETTING AND REMEMBERING. C. T. Rutherford\*. Dept. of Psychology, Univ. of Va., Charlottesville, Va. 22901

To study differential effects of concreteness on recognition memory, tape recordings were made containing numbers, low concrete words, or high concrete words as stimuli. Each stimulus was followed by either an instruction to "remember it," or "don't remember it." Words were all polysyllabic, equally frequently encountered nouns (Thorndike & Lorge, 1944, frequencies of A and AA), differing in their positions on the concreteness dimension (Paivio, Yulish, & Madigan, 1968). On recognition tests that followed the playing of the tapes, subjects correctly accepted and rejected more high concrete words than low concrete words, and more low concrete words than two-digit numbers,  $F(2, 114) = 128.01, p < .001$ . Significantly more "remember" items were recognized than "don't remember" items,  $F(1, 114) = 111.64, p < .001$ . There was no statistically significant interaction with concreteness. The retrievability of a trace in episodic memory is related to the arithmetic sum of the stimulus' concreteness and amount of rehearsal during encoding.

THE CONSULTANT-TEACHER WORKSHOP: A PLAN FOR TEACHER INVOLVEMENT IN SCHOOL PSYCHOLOGICAL SERVICES. M.W. STETTER\*. Dept. of Psychology, Madison College, Harrisonburg, Va. 22801.

The Consultant-teacher workshop approach was investigated as a possible mode of psychological consultation and teacher training in the schools. Prior to the workshop, a single group of 30 elementary-level teachers completed a rating scale regarding perceived functions of the school psychologist, school issues of concern to teachers, and attitudes toward group workshops. The workshop focussed on the issue of most concern to the group—behavior problems in the classroom. In the workshop itself, resource leaders, brief formal presentations, visual aids, and mini-discussion panels were incorporated into a brief, structured format. Subsequent to the workshop, the group again completed the rating scale. The results supported the application of the workshop within a comprehensive program of psychological services to the schools. Results further suggested that a regular schedule of consultant-teacher workshops could serve to generate an equal partnership between psychologists and teachers, leading to effective solution of problems of concern to both groups.

EFFECTS OF INSTRUCTIONS AND ENVIRONMENTAL LITTER ON LITTERING AND DISPOSAL BEHAVIORS. M. A. Tuso and E. S. Geller. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Our past research demonstrated that several people will respond in specified ways to initiate a recycling process if specific instructions are included on reusable commodities. The present research studied the independent effects of a dirty environmental setting and a written message requesting littering on disposal behaviors.

For eighteen consecutive weekdays customers entering a grocery store were given handbills listing specially-priced items. The handbills were distributed daily for a two-hour period. On alternate days the experimenters systematically littered the store with 140 handbills, and for two consecutive weeks the distributed handbills included the message, "Please litter, dispose on floor." The experimenters made daily recordings of where in the store customers deposited their handbills and how many handbills were deposited at specific locations. Both the written litter prompt and the littered environment increased littering above Baseline levels, but the prompt was consistently more influential. This finding suggests that written messages have a marked influence on individuals even when their compliance implies anti-social behavior.

SUPPRESSION OF WATER INTAKE IN THE PRESENCE OF A SECONDARY REINFORCER PREVIOUSLY CONDITIONED TO THIRST REDUCTION. Brian L. West and Frederick J. Kozub. Dept. of Psychology, Univ. of Richmond, Richmond, Va. 23173.

Pairing of a CS with one half hour of water deprivation decreased water intake in rats in the presence of the CS. Similar "low-drive" CS states previously used as control comparisons in three past acquired appetitive drive experiments (Calvin, Bicknell and Sperling, 1953; Ensco, Monk, Kozub and Blick, in press; Solomon and Swanson, unpublished.) were replaced with CS naive subjects. Results indicate that although all three studies based statistical analysis on inappropriate controls, support for the demonstration of an acquired drive was found. Absence of the non-appetitive intermediate stimulus, "thirst fear", failed to extinguish intake reduction. The active secondary reinforcer was concluded to be based on thirst reduction as the primary reinforcer.

ATTRIBUTION OF PERSONALITY DISPOSITIONS AS A FUNCTION OF CHOICE, HEDONIC RELEVANCE, AND EXPECTATIONS OF FUTURE INTERACTION. M. C. Williams\*. Col. of William and Mary, Williamsburg, Va. 23185

Each S (freshman male) expected either to work with a partner (C, undergrad. female) or to work separately on a future anagram task. After meeting briefly, S and C were separated to rate their first impressions of each other. Supposedly due to a malfunction in the sound system, S overheard a comment by C about him. The comment was either positive, negative, or neutral and was said either with or without coaxing (i.e. low or high choice, respectively) by E. The following hypotheses were made: 1. Expecting interaction should result in more extreme dispositional attributions to C except when C's comment is negative--then more neutral attributions should occur than when no interaction is expected. 2. High choice conditions should result in more extreme attributions than low choice. 3. An attribution's valence should match the valence of C's comment in general direction. Also, a negative comment should result in more extreme attributions than a positive or neutral comment. 4. An interaction effect should occur between the independent variables. 5. The degree of certainty with which ratings are made should correspond with the extremeness of the attributions. Preliminary analyses of the data indicate strong support only for Hypothesis 3, with C being rated as significantly less considerate, warm, friendly, and likable in the Negative conditions than in either Positive or Neutral conditions.

A TAXONOMY OF INSTRUMENTAL CONDITIONING. Paul J. Woods, Dept. of Psychology, Hollins College, Roanoke, Va. 24020.

A classification scheme for the operations involved in instrumental conditioning is proposed along with a meaningful nomenclature. The scheme involves four dichotomous dimensions resulting in sixteen categories. While they all appear to be valid almost half of them have never been studied in the laboratory.

## Abstracts of Papers

# Section of Space Science and Technology

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

A COMPUTER LANGUAGE FOR USE IN THE FIELD OF COMBINATORICS. Charles L. Martin\* and D. S. Richards\*, Appl. Math. & Computer Sciences, University of Virginia, Charlottesville, Va. 22901

A computer language designed for use in the field of combinatorics is presented. The major design considerations of the language were: special data types and associated operators, program modularization, iteration, and recursion. The language is implemented using a translator-interpreter.

AN OUTPUT COMMAND CONTROL SYSTEM. E.M. Cliffe and F. H. Lutz, Dept. of Aerospace and Ocean Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

In most flight situations the pilot is seeking to achieve some prescribed flight condition. In particular for a landing approach he may be interested in commanding flight path angle and velocity. A two segment landing approach would require two different values of these variables at different points of the flight path requiring a change of controls during approach. Current automatic flight control systems generally are designed to operate in the neighborhood of some reference state related to the aircraft's current or past equilibrium condition. Therefore commands by the pilot tend to drive the system away from the equilibrium point. Recently proposed control systems using digital computers allow more sophisticated control systems to be implemented. The purpose of this paper is to investigate a digital control algorithm called an output command system which operates so that the pilot commands drive the system toward an equilibrium point. In such a system the pilot's controls serve to command a desired (constant) output. The controller and associated algorithm computes and sets the control positions necessary to drive the aircraft to the selected output and maintain it.

The aircraft used to demonstrate this control scheme was an externally blown flap vehicle (EBF-STOL) in a landing configuration. The outputs commanded are the velocity and flight path angle with the controls of elevator, flaps and throttle.

SUSPENDED SEDIMENT MEASUREMENT BY REMOTE SENSING IN THE COASTAL ZONE OF VIRGINIA. Dr. Robert W. Johnson\*, NASA Langley Research Center, Hampton, Virginia 23665

Suspended sediment is an important environmental parameter for monitoring water quality, water movement, and land use in the coastal zone of Virginia. Techniques for qualitative and quantitative determinations of suspended sediment by analysis of multispectral scanner digital data are described and demonstrated. Remotely sensed data from the LANDSAT satellite platform are considered. Quantitative suspended sediment concentrations determined by remote sensing approach the accuracy obtained by conventional sampling and plotting techniques.

DEPTH DEPENDENT SPECTRAL CHARACTERISTICS OF THE CHESAPEAKE BAY WATER. Norman Cohen\*, and Jacob Becher\*, Department of Physics & Geophysical Sciences, Physics Research Lab., Old Dominion University, Norfolk, Virginia 23508.

Recent interest in multi-channel ocean color sensing have necessitated in situ measurements of radiation as a function of water depth. We shall report on an instrument that has been designed to make these measurements. The instrument measures the intensity of radiation from the sun passing through a column of water as well as the upwelling radiation from lower layers. The spectral features are controlled by employing a band pass filter wheel and the radiation is detected by PIN photodiodes.

Data is transmitted to the surface by multiplexed sub-carrier oscillators and recorded on an audio tape recorder for later analysis. The indications from a preliminary study are that the upwelling radiation as well as the absorption coefficients depends strongly on the station being observed.

VISCOUS OSCILLATING FLOW OVER A SWEEPED BACK WING. T. R. Gupta and D. P. Telionis, Dept. of Eng. Science and Mech., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The unsteady three dimensional boundary-layer equations have been studied for a viscous oscillating flow over a swept-back wing. Gupta<sup>1</sup> studied the effects of cross flow when the cylindrical wing is in arbitrary motion in the chordwise direction and the outer flow is steady. A modified problem is discussed here and a general method is developed for finding solutions of flows past a yawed infinite wing when the outer flow distribution is assumed in the form  $U(x,t) = U_0(x) + e^{i\omega t}U_1(x)$  and  $W(x,t) = W_0 + W_1e^{i\omega t}$ . A similar form is assumed for the response of the boundary layer:  $u(x,y,t) = u_0(x,y) + e^{i\omega t}u_1(x,y)$ ,  $v(x,y,t) = v_0(x,y) + e^{i\omega t}v_1(x,y)$ ,  $w(x,y,t) = w_0(x,y) + e^{i\omega t}w_1(x,y)$ . A perturbation technique yields partial differential equations for  $u_1, v_1, w_1, i=0,1$ . The solutions are developed in an expansion in powers of  $x$  for large and small frequencies following the two-dimensional analysis of Lighthill<sup>2</sup>. A set of ordinary differential equations is obtained from which the flow about a general body configuration for an arbitrary  $U_0(x)$  can be determined. In particular the flow past a yawed infinite wedge as well as the flow past a configuration involving adverse pressure gradients and separation is discussed. The effect on the cross flow is examined and results are presented for separating flow.

1. Gupta, T.R., Proc. Nat. Acad. Sci. India, 42 (A), IV (1972). 2. Lighthill, M.J., Proc. Roy. Soc., 224, 1-23 (1954)

A-C LOSSES AND SUPERMAGNET GEOMETRY. T. V. Pierce, Jr.\* Dept. of Engineering Science and Systems, Univ. of Va., Charlottesville, Va., 22901

Experiments on superconducting magnet coils shows that a-c losses in the mixed state can, to a useful accuracy, be predicted by theoretical models. These models show a-c losses in supermagnets to be affected by coil geometry, and methods are discussed by which these losses can be minimized through improved coil geometry.

MEASUREMENTS OF STRATOSPHERIC DUST BY LASER RADAR. Ellis E. Remsburg and G. Burton Northam\*, Environmental and Space Sciences Division, NASA Langley Research Center, Hampton, Va. 23665

During November and December of 1974, Virginia skies exhibited increased coloration at sunrise and sunset. This was the result of preferential scattering of the different colors by dust particles in the lower stratosphere (13-21 kilometers). This increase in the stratospheric dust layers is being monitored remotely by a ground-based ruby laser radar capable of giving a profile of particle backscatter as a function of altitude.

The appearance of the dust, believed to be due to a volcanic eruption in Guatemala in mid-October, is correlated with the lower stratospheric wind patterns over Virginia. Current stratospheric particle concentrations have not been present over Virginia since 1963. Studies of these events are important in assessing the natural variability of stratospheric constituents and their effects on long term climatic trends.

ON THE POSSIBILITY OF SKIN FRICTION DRAG REDUCTION BY A RESONANT SURFACE BY R. L. Ash, Old Dominion Univ. Dept. of Mechanical Engineering and Mechanics, Norfolk, VA 23508

Previous experiments on skin friction drag reduction by compliant surfaces beneath turbulent boundary layers have been examined. In addition, experiments currently in progress at NASA Langley Research Center have been employed to help explain how drag reduction by a compliant surface is possible. Although a complete theoretical understanding of the phenomenon does not exist, several trends have been identified, and two conceptual models are proposed. The actual mechanism for drag reduction is not surface compliance, but rather appears to be surface resonance. That is, the turbulent wall pressure fluctuations excite the surface and cause it to vibrate.

Two mechanisms have been proposed to explain how surface motions can alter the turbulent energy spectrum. The direct interaction model assumes that surface motions interact directly with the attached low speed portion of the turbulent boundary layer to effectively reduce the average value of the wall shear stress. The acoustic interaction model assumes that the resonant surface radiates sound at a particular frequency which disrupts the turbulent energy cascade in the outer portion of the boundary layer and reduces the rate of turbulence production. Both models are currently being examined experimentally.

SUPERSONIC BOUNDARY-LAYER FLOWS WITH HYDROGEN INJECTION. A. L. Murray\* and C. H. Lewis, Dept. of Aerospace Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A finite-difference method has been developed which may be used to simulate supersonic combustion. The method may be applied to both normal and tangential slot injection. A four species, multi-component diffusion model was used to predict the thermodynamic and transport properties. The chemical behavior was approximated by a flame sheet model which required that combustion occur only at the flame sheet location. Comparisons were made with both numerical and experimental investigations. The solutions are in reasonable to good agreement with other numerical works for normal injection and in good agreement with the peak temperature and species concentration values taken from experimental data.

ON THE STRUCTURE OF THERMALS AT HIGH REYNOLDS NUMBERS.

Mohamed Gad-el-Hak\* Dept. of Engineering Science and Systems, Thornton Hall, School of Engineering and Applied Science, University of Va., Charlottesville, Va. 22901

Laboratory studies of buoyant vortex bubbles and thermals in an unstratified atmosphere are presented. Thermals are generated by filling a soap bubble with a combustible mixture inside a cylindrical box with a sharp-edged orifice at its top. Detailed temperature field measurements are obtained using an array of hot wire probes operating at low overheat. The temperature signals are digitized and different statistical quantities are obtained using an ensemble-conditional averaging technique. It is found that initial conditions do have a strong effect on the development and growth of a thermal, even for gross parameters such as the "entrainment coefficient."

EFFECT OF SURFACE PROPERTIES ON THE ADHESION OF TITANIUM PANELS. T. A. Bush\*, M. E. Counts\* and J. P. Wightman. Chem. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Scanning electron microscopy, electron spectroscopy for chemical analysis (ESCA), and infrared reflectance spectroscopy were employed to characterize titanium alloy (Ti-6Al-4V) surfaces before and after bonding with polyimide resins. Scanning electron microscopy was used to observe the titanium alloy surfaces after various pretreatments and the surfaces of fractured joints. ESCA spectra were obtained for the cleaned alloy surface and for fracture surfaces. The intensity of the titanium peak in the ESCA spectra was related to the presence of thin polyimide films. Specular reflectance infrared spectroscopy was used in the analysis of the fracture surfaces. [Work supported by NASA: Contract NAS1-10646-25].

EXPERIMENTAL STUDIES ON THE AERODYNAMIC PERFORMANCE AND DYNAMIC RESPONSE OF FLOW DIRECTION SENSING VANES. P. S. Barna, G. R. Crossman\*, School of Engineering, Old Dominion Univ., Norfolk, Va. 23508.

Systematic investigations were performed on flow sensors to obtain their performance characteristics and determine their potential for possible application to wind vanes: (a) Single vanes (flat plates) of various planforms with aspect ratios (AR) ranging from .5 to 5 (b) Bi-vanes of rectangular planform with variable trim angles with an AR of 2.5 (c) Cruciform configurations of various planforms with an AR of 2.5 (d) Other three-dimensional models with an AR of 2.5

These models were subjected to wind tunnel tests at Old Dominion Univ. Damping and frequency tests and lift and drag force measurements were performed under a variety of flow conditions with Reynolds number ranging from  $3.0 \times 10^5$  to  $1.3 \times 10^6$ .

Conclusions were drawn as to vane applicability where any of the following may be needed: (1) best damping, (2) fastest frequency response, or (3) shortest response time. Results are represented by numerous tables and graphs. (Funded by NASA Contracts NAS1-9434-49 and NAS1-11707-10,40)

EVALUATION OF A THORIA COATED ITRIDIUM CATHODE FOR AN ION SOURCE.

F. P. Clay, Jr., Physics & Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508; L. T. Melfi, Jr., NASA Langley Research Center, Hampton, Virginia 23665 and F. J. Brock\*, Physics & Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

A thorium coated iridium cathode for use in an ion source, that may be operated in an oxygen atmosphere, has been fabricated and evaluated. The cathode exhibited no irreversible resistance change after operation in an oxygen atmosphere. The work function of the cathode is dependent on the ambient  $O_2$  pressure.

Measurements were made of cathode resistance and heater power demand as a function of  $O_2$  pressure ( $1.4 \times 10^{-9}$  to  $6.5 \times 10^{-4}$  Torr) while the emission was maintained at 100  $\mu$  amp. The heater power required to produce 100  $\mu$  amp emission is approximately .8 watt when the  $O_2$  pressure is less than  $10^{-9}$  Torr, and approximately 1.7 watt at  $6.5 \times 10^{-4}$  Torr.

PROJECT VIKING-MISSION TO MARS. George D. Sands\*, Mail Stop 159, NASA-Langley Research Center, Hampton, Virginia 23665.

On July 4, 1976, NASA will help celebrate the Bicentennial of the American Revolution when it soft-lands an unmanned Viking spacecraft on Mars to search for life. Viking will be the first U.S. spacecraft to land on the surface of another planet.

As part of NASA's continuing planetary exploration program, Viking's purpose is to conduct scientific investigations of the planet Mars with special emphasis on life detection.

To accomplish this goal, two spacecraft will be launched from Cape Kennedy within a month of each other in mid-1975 and cruise 400 million miles through space for nearly a year before reaching their destination. The Viking spacecraft, each consisting of an orbiter and a lander, will then conduct their scientific investigations of the Red Planet.

The Viking Project will be described, with particular emphasis on its thirteen scientific investigations.

SUPERSONIC TURBULENT BOUNDARY-LAYER FLOWS WITH MASS INJECTION THROUGH SLOTS AND/OR POROUS WALLS. A. L. Murray\* and C. H. Lewis. Dept. of Aerospace and Ocean Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

An implicit finite-difference method was used to solve the compressible boundary-layer equations. The method was used to study the effects of mass transfer through porous plates, injection through tangential slots, and a combination of the two. The effects of the external pressure field were also included by using a global pressure interaction scheme. Two different eddy viscosity models were used for the slot and slot/porous combination cases. One was a two-layer model with inner and outer laws. The other was a multi-layer model with as many as five separate layers. Results of the present method were compared with experimental data at  $M = 2.8$ . Comparisons of the skin friction reduction and Mach number profiles gave reasonable to excellent agreement.

A VORTICITY SHEEDING PHENOMENON IN THE WAKE OF AN AIR JET IN A CROSSFLOW. J. M. Kuhlman, Dept. of Mechanical Engineering, Old Dominion Univ., Norfolk, Virginia 23508.

An alternating unsteady shedding of vorticity is found to occur in the lee of a circular air jet issuing from a flat plate at right angles to a uniform stream. The phenomenon is observed as a randomly initiated plate surface pressure fluctuation which is partially deterministic in that pressures at points located symmetrically about a line along the flow direction through the jet origin are always out of phase. Oscillation frequency and amplitude are correlated versus jet Reynolds number,  $Re = U_j d / \nu$  and the jet-to-crossflow velocity ratio,  $R = U_j / U_\infty$ .

Oscillation frequency,  $f$ , is nearly constant and slightly below 1 Hz. As  $R$  decreases  $f$  increases slightly. Strouhal number,  $St = f d / U_\infty$ , is on the order of  $10^{-3}$ , 2 orders of magnitude below values for the vortex street. Maximum fluctuation amplitude is 4% of the crossflow dynamic pressure; this occurs at a velocity ratio of  $R=2$ . Here turbulent eddy generation is expected to be influenced both by the jet shear layer and separation of the crossflow around the jet. Comparison between jets with and without obstructing centerbodies mounted symmetrically in the jet indicate that the centerbody greatly reduces oscillation amplitude. (Aided by NASA grant NGL 039)



AIRPLANE DECOUPLED CONTROL. H. A. Hamer\*, NASA, Langley Res. Center, Hampton, Va. 23665

The principle of decoupling can be briefly stated as:

(1) Choose the response quantities to be controlled.  
(2) Provide one input channel for each quantity. (3) Design the control system so that an input command in one channel causes no response in the other channels. Such an automatic control system could be highly desirable for STOL aircraft operation where severe requirements are placed on precise control during approach and landing.

An exploratory study has been conducted on the Externally Blown Flap STOL. Computer simulations of several two-controller and three-controller decoupled configurations were investigated to ascertain their practical utilization. An error analysis was performed to determine the effects of the major error sources on the decoupling process. The errors considered were: (1) change in flight conditions, (2) imperfect knowledge of airplane dynamic characteristics, and (3) imperfect measurements of airplane state responses.

It was concluded that a two-controller configuration would generally not be acceptable for precision maneuvering. A three-controller system for controlling  $V$ ,  $\gamma$ , and  $\delta$  gave satisfactory results. The control motions were moderate, and the gain magnitudes were not excessive. The error analysis showed that despite large errors imposed on the system, there were no unacceptable effects on the decoupling process. The effects on the control motions were small and no large coupling effects or instability problems developed.

AN EXPERIMENTAL INVESTIGATION OF AN AXISYMMETRIC JET IN A COFLOWING AIR STREAM. George D. Catalano\* and J. B. Morton, Dept. of Engineering Science & Systems, University of Virginia, Charlottesville, Va. 22901

An experimental investigation of the flow development of an axisymmetric jet exhausting into a moving air stream has been made. The flow field of the axisymmetric jet was examined at locations varying from approximately zero to eight diameters downstream of the orifice. The investigation was limited to one Reynolds number due to limitations of the air pressure available in the laboratory. Of primary concern at each downstream location was the mapping of the one point statistical properties of the flow, including mean velocity, turbulent intensity and intermittency. Auto-correlations and power spectral density curves were determined for both the fluctuating velocity field and the concentration signal at various distances from the jet's center line for different downstream locations.

A laser-Doppler anemometer was used to make the desired velocity field measurements. The anemometer used a phase locked-loop processor. The measurements taken with the laser velocimeter were compared with hot wire anemometer and pressure probe data.

To determine the intermittency profiles, auto-correlations and power spectra, a laser light scattering technique was employed. (Work supported by NASA Grant No. NGR 47-005-219 and NSF Grant No. GK 40126).

GOLD PLATING-BRAZING OF ION SOURCE COMPONENTS. L. T. Melfi, Jr., and R. A. Outlaw. NASA Langley Research Center, Hampton, Va. 23665, J. E. Rueser\*, and F. J. Brock. Dept. of Physics and Geophysics, Old Dominion University, Norfolk, Va. 23508.

Vacuum brazing of metalized (Mo-Mn/Ni) aluminum oxide to Kovar with pure gold as the braze alloy is discussed. To insure optimum wetting, each part was gold plated before brazing, using a citric acid-KAu(CN)<sub>2</sub> plating solution. SEM micrographs are presented of the Kovar substrate before and after vacuum firing. Micrographs of the gold plating on the Kovar indicate substantial epitaxial growth. A cross section of the interface (x 11,000) shows the intimacy of the gold Kovar bond. This technique has been found to produce a void free, high purity braze joint.

MEASUREMENT OF THE GAS DENSITY OF URANIUM HEXAFLUORIDE BY LASER RAMAN SCATTERING. William F. Adolfsen\* and R. G. Schlecht and J. B. Morton, Dept. of Engineering Science and Systems, University of Virginia, Charlottesville, Virginia 22901

This investigation demonstrates the feasibility of using laser Raman scattered light to measure the local gas density of Uranium Hexafluoride over the pressure range 15-80 Torr. After a review of the pertinent concepts describing the Raman effect, quantitative results of the frequency shift of the first fundamental vibration, depolarization ratio, polarization of the scattered light, and Raman peak differential cross section are presented. An intensity-density curve was determined over the given pressure range.

The limitations of this technique and its instrumentation is briefly discussed.

## Abstracts of Papers

### Section of Statistics

Fifty-third Annual Meeting of the Virginia  
Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

USING A PROGRAMMABLE COMPUTER FOR STATISTICAL ANALYSES IN ANIMAL SCIENCE RESEARCH. K. P. Bovard, Animal Science Department, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

For the past nine months, both graduate students and faculty in the Animal Science Department at VPI have made increasing use of a programmable computer for statistical analyses of experimental data. They include preliminary analyses for preparation of progress reports and to inspect early results for indications of trends, as well as final analyses of certain studies being prepared for publication. Programs in use include chi-square, both  $2 \times 2$ , and  $r \times 2$ ; linear and quadratic regressions; hierarchical analyses of variance for a single classification of data on one or several variables; and factorial analyses of the form  $A^*B$ , or  $A^*B^*C$ . Examples from nutrition studies and from breeding experiments will be presented and discussed.

AN ALGORITHM FOR IMPROVING CERTAIN MULTIDIMENSIONAL DESIGNS. Wilkie W. Chaffin\* and Klaus H. Hinkelmann. Dept. of Statistics, Hollins College, Roanoke, Va. and Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va.

In many real world problems, a design that allows for some economy of experimentation may be preferable to a balanced or completely orthogonal design. A procedure is described to improve an existing design when it is impractical or impossible to increase the number of design points or to alter the number of replicates of any factor level.

Eccleston and Hedayat (1974) describe an interchange algorithm that may be used to change a proper randomized block design that is connected (as defined by Bose, 1947) to a pseudo-globally connected design (as defined by Eccleston, 1972). This procedure yields a design that provides an increased number of estimates for main effect linear contrasts and is better for treatments according to the S-optimality criterion.

This work describes how such an interchange can be applied to multidimensional designs if the assumption of no interaction is appropriate. Under certain conditions, such a design can be pseudo-globally connected (pg-connected) and made S-better for a factor,  $F_i$ , without the restriction that any of the other factors be equally replicated. Then it is shown that certain designs can be pg-connected and improved with respect to C-optimality (described here for the first time) for any two of the factors in the design.

ON DETERMINING THE LEVELS OF TREATMENT TO OPTIMIZE THE PROBABILITY OF A FAVORABLE RESPONSE. S.L. Crews\*, W.H. Carter, G.L. Wampler\*, and R. Howells\*. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va.; Dept. of Biostatistics, Dept. of Medicine, and Dept. of Radiology, Medical College of Va., Richmond, Va. 23298.

Combinations of drugs are currently being used as an effective treatment for various diseases. A procedure is desired to obtain the dosages of the various agents used in combination which will maximize the probability of a favorable response. The first step is to build a model which relates the probability,  $p_n$ , of the  $n$ th individual responding favorably to the levels of the independent variables. The logistic function has been used in this type of situation where the data are dichotomous. In order to find optimal levels of the doses, the method of ridge analysis can be used for optimization while constraining the results to the region of experimentation.

COMPUTER SIMULATION OF TREE AND STAND GROWTH IN LOBLOLLY PINE PLANTATIONS. R. F. Daniele,\* Division of Forestry and Wildlife Resources, VPI & SU, Blacksburg, Va. 24061

A FORTRAN based simulator is being developed to model growth in managed loblolly pine plantations using individual trees as the basic growth units. In the model, trees are assigned coordinate locations in a stand and "grow" annually as a function of their size, the site quality, and the competition from neighbors. Dimensional relationships were developed using least squares. Growth increments in diameter and height are adjusted by stochastic elements representing genetic and environmental variability. Mortality is generated stochastically through Bernoulli trials. Subroutines are being developed to simulate the effects of site preparation, thinning and fertilization on tree and stand development. Preliminary results indicate that, compared to stand-level models used in the past, the simulator is more closely related to biological growth processes and more flexible in terms of growth and yield estimation and evaluation of alternatives under a wide range of management regimes.

**THE STOCHASTIC DEPENDENCE OF SECURITY PRICE CHANGES AND TRANSACTION VOLUMES.** T. W. Epps<sup>\*</sup>  
Dept. of Economics, Univ. of Va., Charlottesville, Va.  
22901

A theory of financial markets based on a two-parameter portfolio model is shown to imply stochastic dependence between transaction volume and the change in the logarithm of security price from one transaction to the next. The change in the logarithm of price can therefore be viewed as following a mixture of distributions, with transaction volume as the mixing variable. For common stocks these distributions (of which the distribution of  $\Delta \log p$  is a mixture) appear to have a pronounced excess of frequency near the mean and a deficiency of outliers, relative to the normal. These findings are consistent with the hypothesis that stock price changes over fixed intervals of time follow mixtures of finite-variance distributions. Tests with corporate bonds data, however, suggest that  $\Delta \log p$  may follow a mixture of infinite-variance distributions. Moreover, sums of  $\Delta \log p$  for up to 64 consecutive transactions show no tendency to converge in distribution to the normal.

**A CASE OF THE PROBLEM OF OPTIMAL STOPPING AND ITS APPLICATIONS.** P. M. Ghare<sup>\*</sup> J. A. Nachlas<sup>\*</sup> and D. M. Miller<sup>\*</sup> Dept. of IEOR, Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061

The optimal stopping problem is concerned with the decision of whether to continue or abandon a sequence of operations. We consider the case described by the following assumptions: (a) the outcome of each operation  $y_j$  is a random variable, (b) there is a fixed horizon  $T$ , (c) the state of the system can be described  $X = X_1 + X_2 + \dots + X_n$ , and (d) the cost is a function of  $X$  and  $T-j$  (the remaining operations).

The paper describes a hierarchy of such problems and describes its applications in the areas of sequential testing, sales advertising, forecasting, and optimization search strategies. The solution procedures are described in terms of the choice of  $k$ , the number of additional operations before stopping, and of the sufficiency of the rules of choice of  $k$ . An illustration is provided for a particular case.

**A GENERAL BIVARIATE BINOMIAL DISTRIBUTION.** M. A. Hamdan<sup>\*</sup> and D. R. Jensen. Va. Polytechnic Inst. and State Univ.

Aitken and Gonin [Proc. Roy. Soc. Edinb. 55 (1935), 114-125] derived a bivariate binomial distribution from fourfold sampling with replacement. Hence, the marginal distributions were binomial with the same index  $n$  (the sample size for the  $2 \times 2$  table) but with different probabilities of success  $p_1$  and  $p_2$ . Hamdan [Inc. Statist. Rev. 40 (1972), 277-280] derived a bivariate binomial distribution having different marginal indices  $n_1$  and  $n_2$  but with equal marginal parameters  $p_1 = p_2$ . The present paper gives a general bivariate binomial distribution with different marginal indices and unequal marginal parameters. Aitken and Gonin's (1935) and Hamdan's (1972) distributions are shown to be special cases of the general distribution derived in this paper. The derivation is based on considering two characteristics with two levels each:  $(A_1, A_2)$  and  $(B_1, B_2)$ . We observe three independent samples: one on both characteristics and one on each separately. We derive first the bivariate factorial moment generating function, which is then expanded in the form of a finite series. Hence, we derive the canonical form of the general bivariate binomial distribution as a series bilinear in Kravtchouk's polynomials. On the basis of the canonical form, the properties of the distribution are studied.

**AN ANALYSIS OF FACTORS CONTRIBUTING SUCCESS TO 'OPEN' PHYSICS LABORATORY PROGRAM AT VPI & SU.** Lubna R. Ijaz, Division of Science Curriculum Research and Evaluation, College of Education, VPI & SU; D. C. Denning<sup>\*</sup>, M. A. Ijaz<sup>\*</sup>, D. A. Jenkins, T. E. Leinhardt, Physics Department, VPI & SU, Blacksburg, Virginia 24061

This study was designed to identify those factors which have helped the innovative 'open' physics laboratory program at VPI & SU. Three factors studied were: (1) Administrator factor: a) His encouragement in initiating the program. b) Necessary financial support. c) Encouragement to the teachers working on the innovative program. d) His knowledge of the rational and operation of innovative curricula. (2) Briefing teacher factor: a) Motivation and enthusiasm toward the program. b) Knowledge of the operation of the program in progress. c) Knowledge of the innovative programs in other areas of science. d) Knowledge of basic psychology to understand student behavior. e) His behavior towards his students. (3) Student factor: a) How enthusiastic they were towards the innovative program. b) Do they understand the concept of the 'open' laboratory. c) Do they learn more in a free atmosphere or under a traditional one? d) Do they feel that the program and the coordinators are helping them to understand more Physics?

Personal interviews were the major source of the information -- a correlation study procedure was used to analyze the data. Results of our evaluation will be discussed.

**BANK HOLDING COMPANIES AND THE PUBLIC INTEREST.** William Jackson<sup>\*</sup> Research Department, Federal Reserve Bank, Richmond, Va. 23261

The competitive behavior of multibank holding company banks is examined by multivariate analysis. Output, portfolio, price, and profitability values of affiliated banks are compared with those of independent banks by correlation, factor analysis, and regression. Multibank holding company banks extend more loans than other banks, particularly commercial loans. They receive higher returns on assets, because they charge more for their loans and hold less cash than other banks. But they pay higher interest for their time and savings depositors than independent banks. They do not have higher profitability or interest rate spreads between loan and time and savings deposit rates than other banks, despite their use of leverage. While many statistically significant differences exist between affiliated and independent banks, other influences such as bank size, bank branching, and the demand for financial services appear to be more important determinants of bank behavior than affiliation with a holding company. (Aided by Conference of State Bank Supervisors and Nat. Defense Education Act grants.)

**CHARACTERIZATION OF THE EXPONENTIAL FAMILY BY ORDER STATISTICS.** A. I. Khuri<sup>\*</sup> Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

Order statistics is used to obtain the following characterization:

**Theorem:** Let  $X_1 \leq X_2 \leq \dots \leq X_n$  be the non-increasing order statistics for a random sample of size  $n$  from a population with an absolutely continuous distribution  $F$ . Let  $(-\infty, \beta) = \{x: 0 < F(x) < 1\}$ , and let  $h(x) = (-\infty, \beta) \rightarrow [0, \infty)$  be a strictly increasing differentiable function. If for some  $m < n$ ,  $E[h(X_m) | X_{m+1} = x] = ah(x) + b$ , then  $F$  has the following form.

- (i)  $F(x) = 1 - \exp[-h(x)/m(b)]$  if  $a=1$ ;
- (ii)  $F(x) = 1 - [1 - (1-a)h(x)/h(b)]^m$  for  $x \in \beta$  if  $0 < a < 1$ ;
- (iii)  $F(x) = 1 - [h(b)]^m [(a-1)h(x) + b(b)]^m$  if  $a > 1$ ,

where  $h \in (-\infty, \beta) \rightarrow (-\infty, \infty)$  and  $(1-a) > 0$ .

**Corollary 1:** The relation  $E[h(X_m) | X_{m+1} = x] = h(x) + b$ , for some  $m < n$ , is true if and only if  $F$  has the form given in (i).

**Corollary 2:** Let  $U_1 = h(X_1)$ ,  $U_2 = h(X_2)$ , ...,  $U_n = h(X_n)$ . Then,  $U_1^m$  and the vector  $(U_2, \dots, U_n)$  are independent if and only if  $E[h(X_m) | X_{m+1} = x] = h(x) + b$  for some  $m < n$ ,  $n \geq 2$ .

SHRINKAGE ESTIMATION IN RESPONSE SURFACE ANALYSIS. L.C. Malone\* R.N. Myers. Dept. of Statistics, VPI&SU, Blacksburg, Va. 24060 and W.H. Carter. Dept. of Biostatistics, Med. Col. of Va., Richmond, Va. 23219

Several attempts have been made to find an estimator of a response which will have a smaller integrated mean square error than existing procedures. In this work another such attempt is made by introducing a shrinkage procedure.

Suppose the true functional relationship between a response  $n$  and  $p$  independent variables is

$$n(x) = \beta_0 + \sum_{i=1}^p \beta_i x_i + \sum_{i=1}^p \sum_{j=1}^p \beta_{ij} x_i x_j + \sum_{i=1}^p \sum_{j=1}^p \sum_{k=1}^p \beta_{ijk} x_i x_j x_k$$

We fit a model  $\hat{y}(x) = b_0 + \sum_{i=1}^p b_i x_i + \sum_{i=1}^p \sum_{j=1}^p b_{ij} x_i x_j + \sum_{i=1}^p \sum_{j=1}^p \sum_{k=1}^p b_{ijk} x_i x_j x_k$ . We show that the  $k_i$  which minimize  $\sum_{i=1}^p (k_i - \beta_i)^2$  are of the form  $k_i = \frac{\beta_i}{1 + \frac{\beta_i^2}{\sigma^2}}$ . We

propose estimating  $k_i$  by  $k_i = \frac{\beta_i}{1 + \frac{\beta_i^2}{\sigma^2}}$  where  $\beta_i$  and  $\sigma^2$  are the usual unbiased least squares estimates of the parameters  $\beta_i$  and  $\sigma^2$ .

Various comparisons are made among the integrated mean square errors of least squares estimation procedures and the proposed procedure. The distribution of  $k_i$  is derived and the probability that the estimated  $k_i$  is closer to the optimal  $k$  than a  $k$  using upper bounds on the parameters is computed.

#### VARIABLE SELECTION IN MULTIVARIATE ANALYSIS.

C. E. McHenry, Department of Mathematics, Old Dominion University, Norfolk, Virginia 23508.

The problem of variable selection in multivariate analysis is a very real and important one to the experimenter. That is, he does not want to measure more variables than is necessary to explain the relationships of interest. For example, this may be due to the time or the cost involved in collecting the data.

By investigating the properties of the Wishart matrices used to test the hypotheses of interest, methods for selecting variables that require a minimum amount of time and computation can be found. A step-up, a step-wise and a procedure for computing the optimum subset for a given subset size are discussed for the general multivariate linear model. Optimum in the sense that Wilks'  $\Lambda$  is minimized.

THE USE OF A SCREENING TEST TO ESTIMATE THE PREVALENCE OF DIABETES. James T. Massey, National Center for Health Statistics, Rockville, Md. 20852

One of the objectives of the National Health and Nutrition Examination Survey (HANES) is to estimate the prevalence of diabetes in the population. Since the standard glucose tolerance test (GTT) is very difficult to administer in a sample survey such as HANES, a simpler GTT has been proposed to screen out potential diabetes before giving the standard GTT to a smaller sample of persons.

A double sampling procedure using optimum allocation has been developed to determine the optimum glucose level to use for screening. The gain or loss in precision has been estimated for a number of screening procedures. The effect of nonresponse as a function of the preliminary GTT score has also been studied.

#### STATISTICAL ANALYSIS OF ASSOCIATION BETWEEN DISEASE AND GENOTYPE.

Paula Norwood and Klaus Hinkelmann, Norwich Pharmacal Co., Norwich, N.Y. 13815, and Dept. of Statistics, VPI&SU, Blacksburg, Va. 24061

In order to describe and analyze association between genotype and disease, two parameters of association of disease with genotype are defined. One is a measure of the association of a disease with allele at a locus; the other is a measure of the effect of allele interaction on the incidence of the disease. They are additive components of a measure of association of disease with genotype that is also defined. The meaning of these parameters is investigated by considering their effect on natural selection and their relationship to the risk to the disease of a relative of someone who is affected by the disease. It is shown that the association of allele and disease is the only component in the association of genotype and disease that plays a role in natural selection. This component of association is also most important in considering recurrence risks of relatives. The component of association of genotype and disease due to the interaction effect of the alleles on the incidence of the disease increases the risk to disease for only those relatives who can have both genes identical by descent to the propositi.

Use of the Computer in Teaching Undergraduate Statistics. Barbara Perles, Norfolk, Virginia 23508.

Study evaluated use of computer for instructional purposes in a group of undergraduate statistics courses. A "before and after" comparison of content in each statistics course revealed that computer usage did not hasten learning process or make possible teaching of more instructional topics. Conversely, it did not impede learning process or diminish number of topics taught. Computer usage greatly changed the way courses were taught. Teaching methods changed from faculty-oriented formal lectures to student-oriented informal combinations of lecture, discussion, independent study and statistics laboratory. Mathematical prerequisites were reduced at several institutions. Faculty felt that computer enabled complex statistical laws and concepts to be easily illustrated and validated. Simulation of experiments, use of realistic statistical problems and less emphasis on methods of calculation encouraged discussion of concepts and theories. Ability of student (in opinion of faculty) to understand basic concepts of statistics was increased. Five behavioral manifestations of student motivation indicated that computer-oriented instruction in statistics improved motivation of students. Motivation and professional satisfaction of faculty were greatly improved. Student use of computer in assignments of other courses and faculty colleagues' favorable impressions of computer-oriented instruction spread computer usage beyond statistics courses.

UMVU ESTIMATION OF  $P(X=Y)$  IN THE EXPONENTIAL CASE. W.R. Pirie and M.A. Hamdan\*, Dept. of Statistics, VPI&SU, Blacksburg, Va. 24061

Let  $X_1, \dots, X_n$  and  $Y_1, \dots, Y_m$  be two independent random samples. Several recent papers have investigated estimators of  $R=P(X=Y)$  in the normal case. Here we assume the two samples are from exponential populations with means  $\lambda_1$  and  $\lambda_2$  respectively, which implies  $R=\lambda_1/(\lambda_1+\lambda_2)$ . Explicit expressions for uniform minimum variance unbiased (UMVU) estimators are obtained for the two cases:

$$\begin{aligned} 1) \quad \lambda_1 \text{ known} \\ \hat{R}_1 = \frac{1}{n-1} \sum_{j=1}^{n-1} \binom{n-1}{j} \frac{(n-1)!}{(n-j-1)!} \frac{(n\bar{x}/\lambda_2)^{-j}}{(n\bar{x}/\lambda_2)^{n-1}} \exp(-n\bar{x}/\lambda_2) \\ 2) \quad \lambda_1 \text{ and } \lambda_2 \text{ unknown} \\ \hat{R}_2 = \begin{cases} \frac{1}{n-1} \sum_{j=1}^{n-1} \binom{n-1}{j} \frac{(n-1)!}{(n-j-1)!} \frac{(m\bar{y}/n\bar{x})^j}{(m\bar{y}/n\bar{x})^{m-1}} & \text{if } n\bar{x} \geq m\bar{y} \\ \frac{1}{m-1} \sum_{j=1}^{m-1} \binom{m-1}{j} \frac{(m-1)!}{(m-j-1)!} \frac{(n\bar{x}/m\bar{y})^j}{(n\bar{x}/m\bar{y})^{n-1}} & \text{if } n\bar{x} \leq m\bar{y} \end{cases} \end{aligned}$$

Both estimators, in addition to being UMVU, are shown to be asymptotically normal and to achieve asymptotically the Cramér-Rao lower variance bound.

The estimators should be useful in comparative reliability studies in many applications. Although the expressions appear rather complicated, in fact they can be computed even on the better hand calculators available (typically for  $n+m \leq 60$ ).

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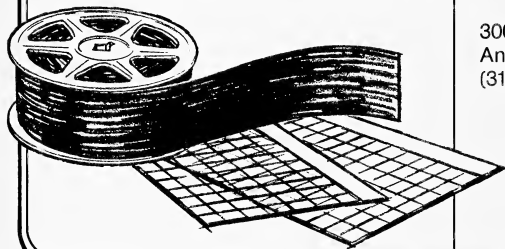
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VOL. 26, NO. 3



FALL 1975



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VIRGINIA ACADEMY OF SCIENCE

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Fall 1975

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Published quarterly by The Virginia Academy of Science, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Second-class postage paid at Richmond, Virginia.

Manuscripts for publication (other than section abstracts) should be sent to the Editor, Dr. David A. West, Department of Biology, V.P.I. and S.U., Blacksburg, Virginia 24061. Proof, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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Manuscript received April 28, 1975

Revised manuscript received June 27, 1975

## A Checklist of the Fishes of West Virginia

**Abstract**—The known and expected fishes of West Virginia are documented. Seven major drainages occur in the state: the Potomac and James of the Atlantic slope; and the Monongahela, Little Kanawha, upper and lower Kanawha system, Guyandotte, and Big Sandy of the Ohio River drainage. 151 species are known from the state with an additional 18 species expected.

### Introduction

A unique and diverse fish fauna occurs in the seven major drainages of West Virginia. Atlantic coast systems that drain montane eastern West Virginia are the Potomac and James Rivers. Other drainages are exclusively of the Ohio River system: Monongahela, Little Kanawha, lower and upper Kanawha, Guyandotte and the Big Sandy Rivers. The authors follow Jenkins, Lachner and Schwartz (1971), among others, who distinguish the Kanawha River as being separated by Kanawha Falls into upper and lower faunal associations. The upper Kanawha system is virtually synonymous with the New River system in ichthyological literature.

West Virginia streams have played a major role in the dispersal of fishes since the Pleistocene. Numerous stream piracies and transfers of fauna between

major drainages have occurred, often leading to isolation and speciation of distinct forms. Geological and biological aspects of the region were recently considered by numerous workers in Holt 1969, 1970, 1971.

Goldsborough and Clark (1908) published the first checklist of the fishes of West Virginia. Other attention was devoted by Addair (1944), Raney (1947), and Raney and Seaman (1950). Osburn (1901) and Trautman (1957) considered the fishes of the main-channel Ohio River. However, a complete checklist has been lacking since this earlier work. Jenkins et al. (1971) presented perhaps the most comprehensive view of the fishes of the state and surrounding drainages. Schwartz (1967), Hambrick et al. (1973), Denoncourt, Hocutt and Stauffer (1975) and Stauffer et al. (1975) recently contributed to an overview of West Virginia ichthyofauna.

151 species representing 21 families are recorded from West Virginia. An additional 18 species are expected to occur (\*). Other forms may be introduced in time. Scientific and common names follow Bailey et al. (1970), except for *Percina crassa roanoka* (Jordan and Jenkins) which is discussed by Hocutt and Hambrick (1973) and Page (1974). The checklist is a preliminary review of the fishes of West Virginia. A diagnostic key and distributional study considering subspecies will follow in the near future.

# Checklist

## Petromyzontidae

<i>Icthyomyzon bdellium</i> (Jordan)	Ohio lamprey
<i>I. greeleyi</i> Hubbs and Trautman	Alleghany brook lamprey
<i>I. unicuspis</i> Hubbs and Trautman	Lamprey
<i>Lampetra aepyptera</i> (Abbott)	Least brook lamprey
<i>L. lamottei</i> (Lesueur)	American brook lamprey

## Acipenseridae

<i>Acipenser fulvescens</i> Rafinesque	Lake sturgeon
<i>Scaphirhynchus platyrhynchus</i> (Rafinesque)	Shovelnose sturgeon

## Polyodontidae

<i>Polyodon spathula</i> (Walbaum)	Paddlefish
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## Lepisosteidae

<i>Lepisosteus osseus</i> (Linnaeus)	Longnose gar
* <i>L. platostomus</i> Rafinesque	Shortnose gar

## Amiidae

<i>Amia calva</i> Linnaeus	Bowfin
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## Anguillidae

<i>Anguilla rostrata</i> (Lesueur)	American eel
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## Clupeidae

<i>Alosa chrysochloris</i> (Rafinesque)	Shipjack herring
<i>A. pseudoharengus</i> (Wilson)	Alewife
<i>Dorosoma cepedianum</i> (Lesueur)	Gizzard shad
<i>D. petenense</i> (Günther)	Treadfin shad

## Hiodontidae

<i>Hiodon alosoides</i> (Rafinesque)	Goldeye
<i>H. tergisus</i> Lesueur	Mooneye

## Salmonidae

<i>Salmo gairdneri</i> Richardson	Rainbow trout
<i>S. trutta</i> Linnaeus	Brown trout
<i>Salvelinus fontinalis</i> (Mitchill)	Brook trout

## Umbridae

* <i>Umbra limi</i> (Kirtland)	Central mudminnow
--------------------------------	-------------------

## Esocidae

<i>Esox americanus</i> Gmelin	Grass pickerel
<i>E. lucius</i> Linnaeus	Northern pike
<i>E. masquinongy</i> Mitchell	Muskellunge
<i>E. niger</i> Lesueur	Chain pickerel

## Cyprinidae

<i>Campostoma anomalum</i> (Rafinesque)	Stoneroller
<i>Carassius auratus</i> (Linnaeus)	Goldfish
<i>Clinostomus elongatus</i> (Kirtland)	Redside dace
<i>C. funduloides</i> Girard	Rosy side dace
<i>Cyprinus carpio</i> Linnaeus	Carp
<i>Erycymba buccata</i> Cope	Silverjaw minnow
<i>Exoglossum laurae</i> (Hubbs)	Tonguetied minnow
<i>E. maxillingua</i> (Lesueur)	Cutlips minnow

## Hybognathus nuchalis Agassiz

## Ilybopsis aestivalis (Girard)

## H. amblops (Rafinesque)

## H. dissimilis (Kirtland)

## H. storeriana (Kirtland)

## \*H. x-punctata Hubbs & Crowe

## \*Notemigonus crysoleucas (Mitchill)

## N. leptocephalus (Girard)

## N. microgogon (Cope)

## N. platyrhynchus Lachner and Jenkins

## Notemigonus crysoleucas (Mitchill)

## Notropis albeolus Jordan

## N. anomeus (Abbott)

## N. analostanus (Girard)

## N. ardens (Cope)

## N. ariommus (Cope)

## N. atherinoides Rafinesque

## N. blennioides (Girard)

## \*N. boops Gilbert

## N. buchananii (Meek)

## \*N. cerasinus (Cope)

## N. chryscephalus (Rafinesque)

## N. cornutus (Mitchill)

## N. dorsalis (Agassiz)

## N. galacturus (Cope)

## N. hudsonius (Clinton)

## N. photogenus (Cope)

## N. procer (Cope)

## N. rubellus (Agassiz)

## N. scabriceps (Cope)

## \*N. semperasper Gilbert

## N. spilopterus (Cope)

## N. stramineus (Cope)

## N. telescopus (Cope)

## N. umbratilis (Girard)

## N. volucellus (Cope)

## N. whipplei (Girard)

## Phenacobius mirabilis (Girard)

## P. teretulus Cope

## P. xanthopterus (Rafinesque)

## P. oreas (Cope)

## Pimephales notatus (Rafinesque)

## P. promelas Rafinesque

## P. vigilax (Baird and Girard)

## Rhynchichthys atratulus (Hermann)

## R. cataractae (Valenciennes)

## Semotilus atromaculatus (Mitchill)

## S. corporalis (Mitchill)

## S. margarita (Cope)

## Silver minnow

## Speckled chub

## Bigeye chub

## Streamline chub

## Silver chub

## Gravel chub

## Hornyhead chub

## Bluehead chub

## River chub

## Bigmouth chub

## Golden shiner

## White shiner

## Comely shiner

## Satinfin shiner

## Roeslin shiner

## Popeye shiner

## Emerald shiner

## River shiner

## Bigeye shiner

## Ghost shiner

## Crescent shiner

## Striped shiner

## Common shiner

## Bigmouth shiner

## Whitetail shiner

## Spottail shiner

## Silver shiner

## Swallowtail shiner

## Rosyface shiner

## New River shiner

## Roughhead shiner

## Sand shiner

## Telescope shiner

## Redfin shiner

## Mimic shiner

## Steelcolor shiner

## Suckermouth minnow

## Kanawha minnow

## Southern redbelly dace

## Mountain redbelly dace

## Bluntnose minnow

## Fathead minnow

## Bullhead minnow

## Blacknose dace

## Longnose dace

## Creek chub

## Fallfish

## Pearl dace

## River carpsucker

## Quillback

## Highfin carpsucker

## Longnose sucker

## White sucker

## Blue sucker

## Creek chubsucker

## Lake chubsucker

## Hog sucker

## Smallmouth buffalo

## Bigmouth buffalo

## Black buffalo

## Spotted sucker

## Silver redborse

## River redborse

## Black jumprock

## Black redborse

## Golden redborse

## Shorthead redborse

## Torrent sucker

##



## Ictaluridae

<i>Ictalurus catus</i> (Linnaeus)	White catfish
<i>I. furcatus</i> (Lesueur)	Blue catfish
<i>I. melas</i> (Rafinesque)	Black bullhead
<i>I. natalis</i> (Lesueur)	Yellow bullhead
<i>I. nebulosus</i> (Lesueur)	Brown bullhead
<i>I. punctatus</i> (Rafinesque)	Channel catfish
* <i>Noturus cleutherus</i> Jordan	Mountain madtom
<i>N. flavus</i> Rafinesque	Stonecat
<i>N. gyrinus</i> Mitchell	Tadpole madtom
<i>N. insignis</i> (Richardson)	Margined madtom
<i>N. miurus</i> Jordan	Brindled madtom
* <i>N. stigmosus</i> Taylor	Northern madtom
<i>Ptylocheilichthys olivaris</i> (Rafinesque)	Flathead catfish

## Percopsidae

<i>Percopsis omiscomaycus</i> (Walbaum)	Trout-perch
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## Cypripodontidae

<i>Fundulus diaphanus</i> (Lesueur)	Banded killifish
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## Atherinidae

<i>Labidesthes sicculus</i> (Cope)	Brook silverside
------------------------------------	------------------

## Percichthyidae

<i>Morone chrysops</i> (Rafinesque)	White bass
<i>M. saxatilis</i> (Walbaum)	Striped bass

## Centrarchidae

<i>Ambloplites rupestris</i> (Rafinesque)	Rock bass
<i>Lepomis auritus</i> (Linnaeus)	Redbreast sunfish
<i>L. cyanellus</i> Rafinesque	Green sunfish
<i>L. gibbosus</i> (Linnaeus)	Pumpkinseed
<i>L. gulosus</i> (Cuvier)	Warmouth
<i>L. humilis</i> (Girard)	Orangespotted sunfish
<i>L. macrochirus</i> Rafinesque	Bluegill
<i>L. nebulosus</i> (Rafinesque)	Longear sunfish
* <i>L. microlophus</i> (Gunther)	Redear sunfish
<i>Micropterus dolomieu</i> Lacepede	Smallmouth bass
<i>M. punctulatus</i> (Rafinesque)	Spotted bass
<i>M. salmoides</i> (Lacepede)	Largemouth bass
<i>Pomoxis annularis</i> Rafinesque	White crappie
<i>P. nigromaculatus</i> (Lesueur)	Black crappie

## Percidae

* <i>Anniocrypta asprella</i> Jordan	Crystal darter
<i>A. pellucida</i> (Putnam)	Eastern sand darter
<i>Etheostoma bleinioides</i> Rafinesque	Greenside darter
<i>E. caeruleum</i> Storer	Rainbow darter
<i>E. caninum</i> (Cope)	Bluebreast darter
<i>E. flabellare</i> Rafinesque	Fantail darter
* <i>E. kanawhae</i> (Raney)	Kanawha darter
<i>E. longimanum</i> Jordan	Longfin darter
<i>E. maculatum</i> Kirtland	Spotted darter
<i>E. nigrum</i> Rafinesque	Johnny darter
<i>E. olivaceum</i> Storer	Tessellated darter
<i>E. osburni</i> (Hubbs and Trautman)	Finescale saddled darter
<i>E. tippecanoe</i> Jordan and Evermann	Tippecanoe darter
<i>E. variatum</i> Kirtland	Variagate darter
<i>E. zonale</i> (Cope)	Banded darter
<i>Percina flavescens</i> (Mitchill)	Yellow perch
<i>Percina caprodes</i> (Rafinesque)	Logperch
<i>P. crassa roanoka</i> (Jordan and Jenkins)	Piedmont darter
<i>P. cupelandi</i> (Jordan)	Channel darter
<i>P. ecides</i> (Jordan and Copeland)	Gilt darter

<i>P. macrocephala</i> (Cope)	Longhead darter
<i>P. maculata</i> (Girard)	Blackside darter
<i>P. notogramma</i> (Raney and Hubbs)	Stripeback darter
<i>P. oxyrhyncha</i> (Hubbs and Raney)	Sharpnose darter
* <i>P. peltata</i> (Stauffer)	Shield darter
<i>P. phoxocephala</i> (Nelson)	Slenderhead darter
<i>P. sciera</i> (Swain)	Dusky darter
* <i>P. shumardi</i> (Girard)	River darter
<i>Stizostedion canadense</i> (Smith)	Sauger
<i>S. vitreum</i> (Mitchill)	Walleye

## Sciaenidae

<i>Aplodinotus grunniens</i> Rafinesque	Freshwater drum
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## Cottidae

<i>Cottus bairdi</i> Girard	Mottled sculpin
<i>C. caroliniae</i> (Gill)	Banded sculpin
* <i>C. cognatus</i> Richardson	Slimy sculpin

**Acknowledgments**—Our appreciation is extended to members of the West Virginia State Game and Fish Commission, who supported this effort. Recognition is given to Lt. Col. Paul A. Patton of the West Virginia Law Enforcement Division, and I. S. Lattimer, Director, West Virginia Department of Natural Resources, who granted permission to collect fishes in West Virginia. Dr. Frank Schwartz provided information on collections he made in the state.

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Manuscript received May 12, 1975

Revised manuscript received July 29, 1975

## The Longitudinal Distribution of the Fishes of the East River, West Virginia-Virginia

**Abstract**—Collections at 13 stations in the East River system, over a two-year period, produced 49 species representing 7 families. *Notropis stramineus* was added to the ichthyofauna of Virginia. Range extensions were established for *Clinostomus funduloides* Girard; *Ercymba buccata* Cope; *Nocomis leptoccephalus* (Girard); *Notropis chrysocephalus* (Rafinesque); *Notropis procer* (Cope); *Notropis telescopus* (Cope); *Notemigonus crysoleucas* (Mitchill); *Pimephales promelas* Rafinesque; *Phoxinus phoxinus* (Cope); *Noturus insignis* (Richardson); and *Etheostoma caeruleum* (Storer).

### Introduction

Two localities on the Virginia portion of the East River were sampled from February-October 1973 (Stauffer et al. 1974) in relation to Appalachian Power Company's Glen Lyn, Virginia, fossil fuel plant. These collections added the sand shiner, *Notropis stramineus* (Cope), to the fauna of Virginia (Jenkins, pers. comm.). Hambrick et al. (1973) discussed two collections from the East River which added the whitetail shiner, *Notropis galacturus* (Cope), and the telescope shiner, *Notropis telescopus* (Cope), to the known West Virginia ichthyofauna. Hambrick et al. (1973) also established distributional records in the East River for the cutlips minnow, *Exoglossum maxillingua* (Lesueur); bluehead chub, *Nocomis leptoc-*

*phalus* (Girard); striped shiner, *Notropis chrysocephalus* (Rafinesque); spottail shiner, *Notropis hudsonius* (Clinton); rainbow darter, *Etheostoma caeruleum* (Storer); and the Roanoke darter, *Percina crassa roanoka* (Jordan and Brayton). The establishment of these records at downstream localities prompted an ichthyofaunal study of the upper East River.

The East River is a 5th order stream which arises in Bluefield, Mercer County, West Virginia, and discharges into the New River 23 miles (37 km) downstream at Glen Lyn, Giles County, Virginia. The East River drains 77.31 square miles (200 km<sup>2</sup>) and has an average gradient of 45.22 ft./mi. (8.56 m/km) (Reger 1925). The valley is bounded by Stony Ridge on the north and East River Mountain on the south.

The geology of the area was determined by Reger (1925) and Chauvin (1957). The immediate valley comprises an outcrop of limestone, while sandstone and sandy shales are present on the south slope and red shales on the north. Reed (1974) attributes the relatively high pH (8.0-8.9) and total alkalinity (139-300 ppm) to the presence of a series of limestone springs in the headwaters.

The state of West Virginia stocks the East River each spring with rainbow trout, *Salmo gairdneri* (Richardson); brown trout, *Salmo trutta* Linnaeus; and brook trout, *Salvelinus fontinalis* (Mitchill). The West Virginia Department of Natural Resources classifies the East River as a high quality stream. However, our observations and a literature review identify five major water quality problems associated with the East River: 1) insufficiently treated and untreated domestic waters; 2) the discharge of oil, grease and detergents from commercial and industrial establishments; 3) silt loads washed into the stream from road construction; 4) the deposition of rubbish along

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the stream banks (Anonymous 1967) and 5) discharge of heated water.

The communities of the East River Valley, and their respective 1970 populations, are as follows: Bluefield, West Virginia (15,921); Kellysville, West Virginia (180); Oakvale, West Virginia (292); Ada, West Virginia (250); Glen Lyn, Virginia (191); Ingleside, West Virginia (75). Bluefield, West Virginia, has the only existing sewage treatment facilities. Kellysville and Glen Lyn discharge untreated sewage directly into the stream (Anonymous 1967). Domestic discharges of raw sewage occur throughout the stream's length.

Run-off from the Norfolk and Western Railway Company's installation in Bluefield, and from the tracks which traverse the entire length of the valley, carry oil, grease and detergents into the river. Run-off from the present construction of U.S. Rt. 460 has increased the sediment load.

Other industrial effluents include treatment waste from the Crowgey Sausage Company, Kellysville; run-off from a quarrying operation upstream from Ingleside; and a heated discharge from Appalachian Power Company's stream electric facility located at Glen Lyn. See Reed (1974) for a more comprehensive discussion of the water quality.

### Methods

Thirteen stations, including the two downstream stations outlined by Stauffer et al. (1974), were established throughout the East River and in its major tributaries (Figure 1). Stations were selected for accessibility but were spaced as evenly as possible throughout the river's length. Rotenone in conjunction with a block net (Hocutt et al. 1973) was used to sample fishes at stations 6, 10, 11, 12, and 13. All other stations were sampled with a 1.2 m  $\times$  3.6 m  $\times$  .64 cm

seine. Each locality was sampled until it was felt that more effort would not produce any additional species. Both riffle and pool habitats were sampled extensively. All specimens were preserved in 10 percent formalin, identified to species and stored in 40 percent isopropyl alcohol in the Virginia Polytechnic Institute and State University Fish Museum (VPISU).

The U.S. Geological Survey 15-minute maps (1:62,500 scale) of Bluefield, West Virginia-Virginia and Narrows, West Virginia-Virginia were used to determine stream order, gradient, altitude and river mile. Horton's (1945) method as discussed by Kuehne (1962) was used to calculate stream order. A map tracer was used to determine gradient and river mile.

### Stations and Collections

1. Km 33.8. East River below Bluefield's water treatment plant. Mercer Co., West Virginia, 25 July 1974. Gradient 11.9 m/km; altitude 716.3 m.
2. Dam Hollow Creek in Bluefield water reservoir (old Ada Dam) due south of Ada, Mercer Co., West Virginia, 18 Sept 1973. Altitude 701 m.
3. Km 30.6. East River at mouth of spring from Ada Reservoir, Mercer Co., West Virginia, 25 July 1974. Gradient 11.2 m/km; altitude 670.6 m.
4. Km 27.4. East River, 2.4 km due west of Box Spring Branch (tributary of East River), Mercer Co., West Virginia, 18 September 1973. Gradient 9.0 m/km; altitude 655.3 m.
5. Km 25.7. East River at Jug Neck Curve 4 km upstream from Ingleside, Mercer Co., West Virginia, 25 July 1974. Gradient 5.9 m/km; altitude 624.8 m.
6. Km 20.9. East River below mouth of 12 Mile Creek, Ingleside, Mercer Co., West Virginia, 18 September 1973; 25 July 1974. Gradient 5.9 m/km; altitude 597.1 m.
7. Km 18.5. East River below Mill Dam, Rt. 12, McKenzie, Mercer Co., West Virginia, 17 September 1973. Gradient 9.0 m/km; altitude 569.4 m.
8. Km 12. East River at mouth of Five Mile Creek, downstream

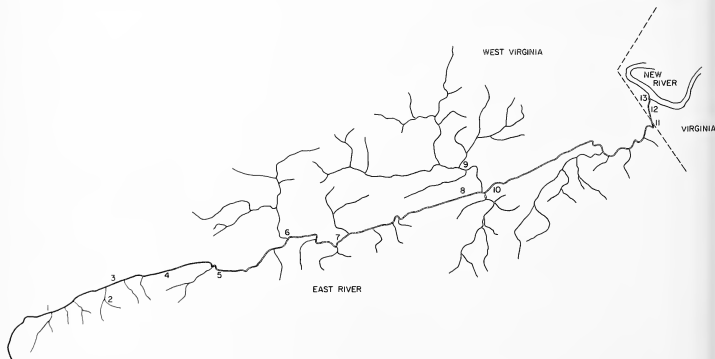


FIG. 1. Map of the East River drainage, West Virginia-Virginia.

- from Oakvale, Mercer Co., West Virginia, 17 September 1973. Gradient 3.0 m/km; altitude 533.4 m.
9. Five Mile Creek at mouth of Hales Branch, Goodwin Chapel, Mercer Co., West Virginia, 17 September 1973. Gradient 9.9 m/km; altitude 558.7 m.
  10. Km 10.4. East River at mouth of Pigeon Creek, Pigeon Creek Road (219-6), Mercer Co., West Virginia, 17 September 1973. Gradient 4.5/km; altitude 518.2 m.
  11. Km 1.2. East River at West Virginia-Virginia State Line. Sampled bimonthly, February 1973—December 1974. Gradient 7.5 m/km; altitude 487.7 m.
  12. Km 0.4. East River below outfall of APCO's heated discharge, Glen Lyn, Giles Co., Virginia. Sampled bimonthly, February 1973—December 1974. Gradient 3.8 m/km; altitude 475.5 m.
  13. Km 0. East River at confluence of New River, Giles Co., Virginia. Sampled bimonthly, February 1973—December 1974. Gradient 1.9 m/km; altitude 457.2 m.

### Results and Discussion

This survey resulted in the collection of 49 fish species in 7 families (Table 1). All species except the rainbow trout, *Salmo gairdneri* Richardson, and brook trout, *Salvelinus fontinalis* (Mitchill) were present in the Virginia portion of the East River. The West Virginia fauna comprised 24 species. Range extensions were established for 12 species.

Rosyside dace, *Clinostomus funduloides* Girard. The Range of the rosyside dace was extended to include the West Virginia portion of the East River. An examination of fishermen's bait buckets revealed that this species was abundant. Records of the VPIU Fish Museum show that the rosyside dace was present in many of the streams in the area. Jenkins and Freeman (1972) reported it as a headwater pool inhabitant in the Roanoke drainage. Burton and Odum (1945) recorded it in Sinking Creek and Spruce Run, New River drainage, Giles County, Virginia. A downstream distributional record in the main channel, New River, was reported in Hocutt et al. (1973).

Silverjaw minnow, *Ericymba buccata* Cope. One specimen, collected at station 12, represents a new distributional record for the New River drainage, Giles County, and adds this species to the ichthyofauna of the East River. The silverjaw minnow did occur in fishermen's bait buckets, although it was not common.

Bluehead chub, *Nocomis leptocephalus* (Girard). Hambrick et al. (1973) collected it at Willowton, West Virginia (km 4.0). The collection at station 6 (km 20.9) represented an upstream distributional record for the bluehead chub in the East River.

Striped shiner, *Notropis chryscephalus* (Rafinesque). Hambrick et al. (1973) established a new distributional record for this species at Willowton, West Virginia. The presence of the striped shiner at station 8 extends this record upstream to km 12.

Golden shiner, *Notemigonus crysoleucas* (Mitchill). The presence of the golden shiner at stations 11 and 12 added this species to the fauna of the East River. As this is a common bait fish, the specimens may represent bait bucket introductions.

Swallowtail shiner, *Notropis proce* (Cope). One specimen of the swallowtail shiner, collected at station 11, added this species to the fauna of the East River. Jenkins et al. (1971) did not list the swallow-

tail shiner in the Kanawha River; however, Hocutt (1974) added this species to the New River fauna. Interviews with fishermen indicated that several of them came from Salem, Virginia. The swallowtail shiner is generally common in some small streams (Roanoke River drainage) of the Salem area (Jenkins and Freeman, 1972); however, no specimens of the swallowtail shiner were observed in bait buckets.

Sand shiner, *Notropis stramineus* (Cope). The collection of one specimen of the sand shiner at station 12 adds this species to the ichthyofauna of Virginia (Jenkins, per. comm.). Jenkins et al. (1971) list it as being native to the Kanawha River above the falls. It is possible that this specimen was attracted by either the warm water or the artificially created sand bottom, which are both created by APCO's fossil fuel plant located at station 12.

Telescope shiner, *Notropis telescopus* (Cope). Hambrick et al. (1973) added the telescope shiner to the ichthyofauna of West Virginia with their collection at Willowton, West Virginia. Our collection of this species at station 8 extended its distribution to km 12. The absence of the telescope shiner at the upstream stations supports the theory of Hambrick et al. (1973) of the upstream dispersal from the New River.

Mountain redbelly dace, *Phoxinus oreas* (Cope). The occurrence of this species at station 11 is the first record for the East River drainage, Virginia.

Fathead minnow, *Pimephales notatus* Rafinesque. Collections at stations 11 and 12 are the first records of the East River. Jenkins et al. (1971) did not find the fathead minnow in the Kanawha River above the falls. Hocutt et al. (1973) established a distributional record for this species in the main channel, New River. Again, these distributional records probably represent bait bucket introductions. This species was present in several fishermen's minnow buckets along the banks of the New River and mouth of the East River.

Margined madtom, *Noturus insignis* ssp. (Richardson). One specimen collected at station 12 was the first record for the East River drainage. Records at the VPIU Fish Museum show that this species is abundant in many of the tributaries of the New River. This record may represent downstream dispersal via the main channel New River.

Rainbow darter, *Etheostoma caeruleum* (Storer). Hocutt et al. (1973) added the rainbow darter to the ichthyofauna of the upper New River, Virginia. The first record in the East River was reported by Hambrick et al. (1973). The presence of this species at station 10 extends the distribution to include the New River drainage, West Virginia.

Other species not collected in this study, but which may be present in the East River, include the tongue-tied minnow, *Exoglossum laurae* (Hubbs); longear sunfish, *Lepomis megalotis* (Rafinesque); finescaled saddle darter, *Etheostroma osburni* (Hubbs and Trautman); and the mottled sculpin, *Cottus bairdi* Girard. The tongue-tied minnow was reported in a collection of Addai (University of Michigan Museum of Zoology: 119174-119183) in the East River, 19.3 kilometers from Princeton, West Virginia. Two specimens of the longear sunfish were collected by

Hubbs and Hubbs (UMMZ:2 specimens 95249) in the East River, Glen Lyn, Virginia. This material was subsequently confirmed by R. E. Jenkins (pers. comm.). Both the finescaled saddle darter and the mottled sculpin have been collected by the authors in the main channel New River.

In addition to the above, Goldsborough and Clark (1908) reported 21 specimens of the emerald shi-

ner, *Notropis atherinoides* Rafinesque, in the East River near Ingleside, West Virginia. Jenkins (1971), however, does not list this species as being present above the falls in the Kanawha River. We feel certain that the records of Goldsborough and Clark represent a misidentification of either the rosyface shiner or the silver shiner.

Station 12, located in APCO's heated discharge,

TABLE 1  
List of species captured in the East River February 1973—December 1974.

Species	Stations									
	13	12	11	10	9	8	7 River Kilometer	6	5	4
	0	.4	1.2	10.4	*	12	18.5	20.9	25.7	27.4
<i>Salmo gairdneri</i>					X					
<i>Salvelinus fontinalis</i>					X					
<i>Camptostoma anomalum</i>	X	X	X	X	X	X	X	X	X	
<i>Clinostomus funduloides</i>		X	X							
<i>Cyprinus carpio</i>			X							
<i>Exoglossum maxillingua</i>	X	X	X							
<i>Ericymba buccata</i>		X								
<i>Nocomis platyrhynchos</i>	X	X	X				X			
<i>N. leptocephalus</i>	X	X	X	X		X		X		
<i>Notemigonus crysoleucas</i>			X							
<i>Notropis albeolus</i>	X	X	X	X		X				
<i>N. ardens</i>	X	X	X							
<i>N. chryscephalus</i>			X			X				
<i>N. galacturus</i>	X	X	X							
<i>N. hudsonius</i>	X	X	X			X				
<i>N. photogenis</i>	X	X	X							
<i>N. procerus</i>		X								
<i>N. rubellus</i>	X	X	X	X		X				
<i>N. spilopterus</i>	X	X	X	X	X	X	X			
<i>N. stramineus</i>		X								
<i>N. telescopus</i>	X	X	X		X	X				
<i>N. v. volucellus</i>	X	X	X							
<i>Phoxinus phoxinus</i>			X							
<i>Pimephales notatus</i>	X	X	X		X	X	X			
<i>P. promelas</i>		X	X							
<i>Rhinichthys atratulus obtusus</i>	X	X	X	X	X	X	X	X	X	X
<i>R. cataractae</i>			X							
<i>Semotilus atromaculatus</i>	X	X	X	X	X		X			X
<i>Catostomus commersoni</i>	X	X	X	X	X		X			X
<i>Hypentelium nigricans</i>	X	X	X	X	X					
<i>Ictalurus punctatus</i>	X	X	X							
<i>Noturus insignis</i>		X								
<i>Pylodictis olivaris</i>	X	X								
<i>Ambloplites r. rupestris</i>	X	X	X	X						
<i>Lepomis aeneus</i>		X	X					X		
<i>L. cyanellus</i>		X	X					X	X	X
<i>L. gibbosus</i>			X							
<i>L. macrochirus</i>		X	X							
<i>Micropterus dolomieu</i>	X	X	X							
<i>M. punctulatus</i>	X	X								
<i>M. salmoides</i>				X						
<i>Pomoxis nigromaculatus</i>		X								
<i>Etheostoma blennioides</i>	X	X	X	X						
<i>E. flabellare</i>	X	X	X	X	X	X	X	X	X	
<i>E. caeruleum</i>		X	X	X						
<i>Percina crassa roanoka</i>	X	X	X							
<i>P. oxyrinchus</i>	X	X								
<i>P. maculata</i>					X					
<i>Cottus caroliniae</i> ssp	X	X	X	X						

\* Station not located on the main channel.

supported the most diverse fauna. It is probable that when the heated discharge provides the preferred temperature of a particular species in the effluent, that species moves into the area (Stauffer 1975; Stauffer et al. 1974).

Excluding the stations located in the heated discharge, the number of species decreased from 37 at station 11 (river km 1.2) to 0 at station 1 (river km 33.8). A natural decrease in the number of species in headwater areas was to be expected (Jenkins and Freeman 1972; Hocutt and Stauffer 1975); however, the decline in the number of species in East River was probably influenced by the presence of organic pollution. This hypothesis was further supported by the complete absence of fish at station 1, which was located immediately downstream of Bluefield's sewage treatment facility.

It should be noted that rotenone was used to sample stations 6, 10, 11, 12 and 13 in 1974. The rotenone collection at station 6 (river km 20.9) did not produce any more species than a seine collection at the same locality had in 1973. It was therefore assumed that the continued use of rotenone upstream of this point would not result in the collection of more species than would careful seining.

In general, we support the conclusions of Hambrick et al. (1973) that the populations of the white-tail shiner and telescope shiner have dispersed upstream from the New River. However, the rainbow darter's presence may reflect a relict population which can no longer inhabit the upper reaches of the East River because of pollution. The margined madtom probably dispersed down the New River from other tributaries to the mouth of the East River. Other distributional records probably resulted from bait bucket introductions.

**Acknowledgments**—Robert E. Jenkins confirmed the records of many of the specimens, identified the one specimen of the sand shiner and provided encouragement throughout the course of the study. D. Bailey, J. Belcher and J. Wilson aided in the collection of specimens. Without the cooperation of E. J. Griffith (conservation officer) and Lt. Col. P. Patton of the Law Enforcement Division, and I. S. Latimer, Director (West Virginia Department of Natural Resources), this study would not have been possible.

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Manuscript received July 7, 1975

Revised Manuscript received July 30, 1975

## The Occurrence of *Diaptomus* (*Skistodiaptomus*) *pallidus* Her- rick and *D. (S.) pygmaeus* Pearse (Copepoda: Calanoida) in Virginia.

**Abstract**—Comments on and records of the distributions of *Diaptomus pallidus* and *D. pygmaeus* in Virginia are presented. These new state records represent significant range expansions, especially for the latter species.

Calanoid copepods have received scant coverage in Virginia. Previously published records (Marsh 1915 and 1929; Hutchinson and Pickford 1932; Coker and Hayes 1940; Grover and Coker 1940; McCalla 1942; Obeng-Asamoah 1971) represent samples from very limited areas and generally span brief time periods. The collections of Marsh were from the vicinity of Washington, D.C. and the rest were from Mountain Lake. The two species of *Diaptomus* herein reported appear to be new for the state. It was not possible to establish whether these species were native or were recent introductions. The relatively recent construction of large impoundments may have provided a habitat not available in the two natural lakes of Virginia (A. Robertson, pers. comm.).

Mountain Lake in Giles County is a distinctly oligotrophic lake at an elevation of 1181 m. *Diaptomus* (*Aglaodiaptomus*) *leptopus* Forbes is the only calanoid known from Mountain Lake and there reaches its southern limit (Wilson 1959). Lake Drummond in the Great Dismal Swamp is a dystrophic bog lake which apparently has no limnetic diaptomids (Anderson 1975). Limnologically these two natural lakes are unlike the impoundments now found in Virginia.

*D. pallidus* has a widespread distribution west of the Appalachians and east of the Rockies (Marsh 1929; Wilson 1959). It has been reported as far east as Pymatuning Reservoir in Pennsylvania (Czaika and Robertson 1968) and Nottely Reservoir in Georgia (Hegyi 1973). Consequently, it is not surprising that we find this species widely distributed within Virginia. Twelve records for this species (see Table 1) have been established based on collections from 22 impoundments throughout the state.

Reports for *D. pygmaeus* have been limited to New England (A. Robertson, pers. comm.) since its original discovery in Massachusetts (Pearse 1905). Consequently, the presence of this species in North Anna Reservoir was thought to be quite unusual and perhaps to be a transitory phenomenon attributable to the newness of the impoundment (filled in 1972). However, continued collecting in that reservoir and additional collections from three impoundments presumed to be old enough to have stable zooplankton communities (Dzyuban 1957) have established that *D. pygmaeus* is a consistent member of some limnetic zooplankton communities in this state (Table 1).

In previous literature I found no mention of the co-occurrence of these two species, yet two such cases are now known for Virginia. This probably represents the first overlap of their geographic ranges, perhaps due to recent extensions by one or both species. There are two additional factors that may have some bearing on the previous lack of reports. First, *D. pygmaeus* was long considered a synonym of *D. oregonensis* (Marsh 1929) so actual records of *D. pygmaeus* may have been missed. Secondly, in cases where only female individuals are available, it may not be possible to distinguish between *D. pallidus* and *D. pygmaeus* using the key by Wilson (1959). The character which she employed—the relative lengths of the lateral marginal setae of the endopod of leg 5—was found to be too variable. (The original published drawings of Pearse in fact appear to contradict the key.) I suggest that this character not be used to distinguish between females in mixed populations until morphometric analysis can establish the extent of the variation. The implications of con-generic (or -sub-generic) occurrences have been discussed in detail by several authors (e.g., Cole 1961; Rigler and Langford 1967; Sandercock 1967).

The distributional records compiled for *Diaptomus pallidus* and *D. pygmaeus* in Virginia represent significant range extensions, especially for the latter species. The present abundance of both species in the state, when no published records are known, demonstrates our ignorance of the zooplankton of Virginia's many impoundments.

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TABLE 1

Locality data for *Diaptomus pallidus* and *D. pygmaeus* in Virginia

*Diaptomus (Skistodiaptomus) pallidus*

City of Newport News. City of Newport News reservoir near state route 143. 1 June 1975

Lake Maury. 1 June 1975

Fairfax County. Burke Lake. 18 May 1975

Lake Fairfax located 3 km. east of Herndon. 18 May 1975

Franklin County. Smith Mountain Lake. A series of collections during 1974.

James City County. Lake Matoka adjacent to the campus of the College of William and Mary. 1 June 1975

Lake Powell at state route 31. 1 June 1975

Reservoir on Skiffes Creek at U.S. route 60. 31 May 1975

Louisa County. North Anna Reservoir. Many collections since 1973.

Montgomery County. Isaac Walton League pond on Den Creek near county route 641 about 8 km SE of Blacksburg. 23 Jan. 1975

Patrick County. Philpott Reservoir. 7 Nov. 1975

York County. Jones Mill Pond in Cheatham Annex at Colonial Parkway. 31 May 1975

Queen Ann's Lake near county route 716 north of I-64. 31 May 1975

*Diaptomus (Skistodiaptomus) pygmaeus*

Albermarle County. Reservoir on South Fork Rivanna River. 17 May 1975

Fairfax County. Lake Fairfax, located 3 km east of Herndon. 18 May 1975

Louisa County. North Anna Reservoir. Many collections since 1973.

Pulaski County. Claytor Lake. Fall, 1974

**Acknowledgments**—The author wishes to thank G. B. Hall, P. Loeffelman, A. L. Saunders, J. F. Saunders, Jr., Dr. A. L. Buikema, Jr. and Dr. G. M. Simmons, Jr. for help in making these collections; Dr. A. Robertson for kindly verifying identifications of calanoids from the North Anna Reservoir and for his valuable comments; and Drs. A. L. Buikema, Jr. and G. M. Simmons, Jr. for comments on the manuscript.

Studies on the North Anna Reservoir were sup-

ported by a grant from the Virginia Electric and Power Company.

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Manuscript received July 3, 1975

Revised manuscript received Sept. 5, 1975

## Records of the Blackbanded Sunfish, *Enneacanthus chaetodon*, and Comments on the Southeastern Virginia Freshwater Ichthyofauna

**Abstract**—The blackbanded sunfish, *Enneacanthus chaetodon*, is recorded for the first time in Virginia, from the inner Coastal Plain of the Chowan system. Additional records, notably for the Roanoke, Tar, and Neuse drainages of North Carolina, supplement those of Sweeney (1972) from other parts of its range. Some of the broad gaps in its overall distribution and localization of populations probably relate to ecological factors and prehistorical changes in sea level.

The freshwater ichthyofauna of southeastern Virginia contains about 70 species. Ecological and physical barriers in the Chowan Fall Line zone apparently are not as sharp or extensive, or so restricted to that physiographic province, as in certain other Atlantic slope drainages. Thus many species typical of either the adjacent Coastal Plain or the Piedmont provinces occur on both sides of the Fall Line. The richness of the Chowan fauna (69 species), compared with that of the Dismal Swamp (25 species), reflects in part its greater age, closer proximity to richer faunal sources, and access to a much greater diversity of habitat.

### Introduction

The blackbanded sunfish, *Enneacanthus chaetodon* (Baird), is a small, secretive sunfish (Centrarchidae) previously recognized in the monospecific genus *Mesognistius*. Mergence of *Mesognistius* with *Enneacanthus*, now containing three species, is based on studies by Branson and Moore (1962) and Sweeney (1972) and is widely accepted. Subgenera were not

recognized. *E. chaetodon* was partitioned by Bailey (1941) into a northern and a southern subspecies, the latter named *E. c. elizabethae*. Sweeney (1972) found that differences are below levels generally regarded sufficient for subspecific recognition.

*E. chaetodon* is a Coastal Plain species, ranging on the Atlantic slope from New Jersey to Florida, and occurring on the northeastern Gulf of Mexico slope in Georgia. Its distribution pattern shows wide disjunctions and localization of populations.

We document the first Virginia collection of *E. chaetodon* and summarize other records of this species, many from generally unavailable state reports, with comments on habitat. Until recently the composition of the ichthyofauna of the Chowan River system (Roanoke drainage) in Virginia was poorly known. Its present fauna is identified according to physiographic provinces occupied, and it is compared with that of the adjacent Dismal Swamp. Many zoogeographic studies have indicated differences among montane, Piedmont, and Coastal Plain faunas. Raney (1950) considered the fishes of the James drainage, adjacent to the Chowan on the north. Jenkins, Lachner, and Schwartz (1972) treated those of central eastern United States, with summary of extensive earlier literature, but generally did not distinguish the Chowan fauna from that of the Roanoke proper. Emphasis herein is on the fauna of the Chowan Fall Line zone and its species that occur in the adjacent Coastal Plain and Piedmont provinces.

## Materials and Methods

Records of *E. chaetodon* plotted in Fig. 1, and additional to those of Sweeney (1972), are listed below. Institutional abbreviations: DU—Duke University; NCSM—North Carolina State Museum of Natural History; RC—Roanoke College; USNM—U.S. National Museum of Natural History.

NJ: 5 coll. (Smith 1953). DE: 2 coll. (Harmic 1952). MD: USNM uncat., Wicomico Co., impoundment Tonytank Cr., Rt. 13, 0.5 mi. S. Salisbury, 26 July 1949 [Smithville Pond records (Schwartz 1961) apparently misplotted by Sweeney (1972)]. Roanoke (Chowan) drainage, VA: USNM 214540, 2 spms., 40, 55 mm std. len., Prince George Co., Blackwater Swamp, Rt. 156 bridge, 2.7 mi. N Rt. 460, 15 July 1973, L. A. and D. S. Revelle, R. S. Strickland. Roanoke (Chowan) drainage, NC: Gates Co., Merchants Mill Pond (Menhinick, pers. comm.). Gates Co., Duke Swamp (Tarpsee, pers. comm.). Roanoke (Roanoke) drainage, NC: NCSM 235-240, 1 local. (Fowler 1945). Albemarle Sound (Alligator) drainage, NC: 1 coll. (Baker and Smith 1965). Tar drainage, NC: DU uncat., Nash Co., Sapony Cr., 2.3 mi. S Nashville, Rt. 58, 1 June 1950 (J. R. Bailey *vide* Menhinick, pers. comm.). Neuse drainage, NC: 5 coll. (Bayless and Smith 1962), 1 of which is NCSM 3732, another uncat. at DU. 1 coll. (Fowler 1945). 1 coll. (Smith 1907). NCSM 233-234, 241-242 Johnston Co., Mingo Cr., 10 Dec. 1924. DU uncat., Johnston Co., outlet Godwins L., 6.5 mi. SSE Benson, 29 Mar. 1960. DU uncat., Nash Co., Toisnet Swamp 3 mi. S Strickland Crossroads, Rt. 97 bridge, 19 June 1961 (last 2 by Bailey *vide* Menhinick, pers. comm.). Northeast Cape Fear drainage, NC: 5 coll. (Bayless 1963). Cape Fear drainage, NC: 16 coll. (Loudner 1963 [where disagreement occurs between Appendices A and B, which is only slight, App. A data are used, as they are closer to orig. data; App. B is summary of App. A]). White Lake (Collette 1962). Peedee (Lumber, Waccamaw) drainage, NC: 26 coll. (Loudner 1962). Savannah drainage, SC: 2 coll. [1 unlocated] (Freeman 1954).

Records for other species of the Chowan system and Dismal Swamp of Virginia (Table 1) are based on 168 collections taken, reported, or housed as follows [number of collections in brackets]: Andrews (1971) [25 "counted," judged to mean 25 colls. are basis of Andrews' table, regarded to include 3 at Cornell University taken by Andrews and at least 4 at Va. Inst. Mar. Sci. taken by W. H. Massmann]. Cornell Univ. [42], includes 27 colls. by Zorach; most others by E. C. Raney; includes 2 from Chowan by Andrews; excludes 3 from Dismal Swamp collected and apparently reported by Andrews (1971). Fowler (1945) [1]. Henningson, Durham and Richardson, Inc. [5] by R. S. Lee and D. Smith, housed at RC. Jordan (1889) [3, excluding first 3 "Dismal Swamp" colls. listed], housed at Cal. Acad. Sci., Univ. Mich., USNM. Lynchburg Coll. [6]. Old Dominion Univ. [6], by R. S. Birdsong, Revelle [14], pers. coll. Smith (1963) [2]. U. S. Bur. Sport Fish. Wildl. [6], by J. R. Sheridan, some housed at RC. USNM [12], most by G. S. Myers; excludes Jordan's material. U. S. Soil Cons. Serv. [3], by R. I. Bonn, mostly housed at RC. Univ. Conn. [6]. Univ. Fla. [3]. Univ. Mich. Mus. Zool. [2], excludes Jordan's material. Univ. N. C., Inst. Mar. Sci. [1]. Univ. Richmond [11], most by W. S. Woolcott. Va. Comm. Game Inland Fish. [11], by R. V. Corning and M. D. Norman; small amt. preserved. Va. Inst. Mar. Sci. [9], most by J. A. Musick; excludes 4 by Massmann included under Andrews (1971). Some records of *Maxostoma* (Jenkins, 1970) and *Nocomis* (Lachner and Jenkins 1971) are based on specimens collected by R. D. Ross, Va. Polytech. Inst. State Univ., and housed at Cornell Univ. and the USNM.

Total Virginia collections indicated above (excluding those by Ross) from each watershed and physiographic province: Meherrin—Piedmont 16, Fall Line 6, Coastal Plain 2; Nottoway—Piedmont 33, Fall Line 14, Coastal Plain 19; Blackwater—Coastal Plain 35; Dismal Swamp—Coastal Plain 43.

Location of Fall Line generally was taken from Fenneman (1938). Its location in the Chowan and

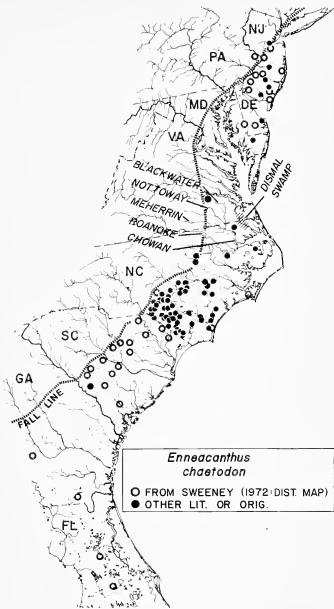


FIG. 1.—Distribution by locality records of *E. chaetodon*. Some records omitted where symbols are crowded.

longitudinal profiles and gradients of certain Chowan streams were determined from a gazetteer and map in Anon. (1972) and U. S. Geological Survey topographic maps, scale 1:24,000. Limits of the Dismal Swamp in Virginia were considered those mapped by Whitehead (1972), supplemented by examination of U.S.G.S. 1:24,000 maps. Ramsey et al. (1970) and the U.S.G.S. Norfolk 1:250,000 quadrangle were used to determine the Swamp boundary in North Carolina.

Common names of fishes listed herein were given by Bailey et al. (1970).

## Habitat

Throughout its range the blackbanded sunfish is largely restricted to quiet, shallow, heavily vegetated, nonturbid, darkly stained, acidic waters of streams, margins of rivers, ponds, and lakes. The single locality of its capture in Virginia is in a typical small, inner

TABLE I

Fishes, listed by physiographic province, of the three branches of the Chowan system (Roanoke drainage) and the Dismal Swamp, Virginia. (+ = native; \* and I = introduced; - = unknown; certain euryhaline species excluded)

Family	Genus	species	CHOWAN			DISMAL SWAMP	
			Meherrin and/or Nottoway		Blackwater	Coastal Plain	Coastal Plain
			Piedmont	Fall Line	Coastal Plain		
Petromyzontidae							
	<i>Lampetra</i>	<i>lamotteni</i>	+	-	-	-	-
	<i>Petromyzon</i>	<i>marinus</i>	-	+	+	-	-
Lepisosteidae							
	<i>Lepisosteus</i>	<i>osseus</i>	-	+	+	+	+
Amiidae							
	<i>Amia</i>	<i>calva</i>	-	-	+	+	+
Anguillidae							
	<i>Anguilla</i>	<i>rostrata</i>	+	+	+	+	+
Clupeidae							
	<i>Dorosoma</i>	<i>cepedianum</i>	-	-	-	+	-
Umbridae							
	<i>Umbr</i>	<i>pygmaea</i>	-	+	+	+	+
Esocidae							
	<i>Esox</i>	<i>americanus</i>	+	+	+	+	+
	<i>E.</i>	<i>niger</i>	+	+	+	+	+
Cyprinidae							
	* <i>Carassius</i>	<i>auratus</i>	-	-	-	I	-
	<i>Clinostomus</i>	<i>funduloides</i>	+	-	-	-	-
	* <i>Cyprinus</i>	<i>carpio</i>	I	-	-	I	-
	<i>Exoglossum</i>	<i>maxillingua</i>	+	+	-	-	-
	<i>Hybognathus</i>	<i>regius</i>	-	-	+	+	-
	<i>Nocomis</i>	<i>leptocephalus</i>	+	+	-	-	-
	<i>N. ranevi</i>		+	+	+	-	-
	<i>Notemigonus</i>	<i>crysoleucas</i>	+	+	+	+	+
	<i>Notropis</i>	<i>albeolus</i>	+	+	-	-	-
	<i>N. altipinnis</i>		+	+	-	-	-
	<i>N. amoenus</i>		+	+	+	+	-
	<i>N. anahostanus</i>		+	+	+	+	-
	<i>N. ardens</i>		+	+	-	-	-
	<i>N. bifrenatus</i>		-	+	-	-	-
	<i>N. cerasinus</i>		+	-	-	-	-
	<i>N. chalybaeus</i>		-	+	+	+	-
	<i>N. hudsonius</i>		-	-	+	-	-
	<i>N. procne</i>		+	+	+	+	-
	<i>Phoxinus</i>	<i>oreas</i>	+	-	-	-	-
	<i>Rhinichthys</i>	<i>atratulus</i>	+	-	-	-	-
	<i>Semotilus</i>	<i>atromaculatus</i>	+	-	-	-	-
Catostomidae							
	<i>Catostomus</i>	<i>commersoni</i>	+	-	-	-	-
	<i>Erimyzon</i>	<i>oblongus</i>	+	+	+	+	+
	<i>E. sucetta</i>		-	+	+	+	+
	<i>Hypentelium</i>	<i>nigricans</i>	+	+	+	-	-
	<i>Moxostoma</i>	<i>antistruum</i>	+	+	+	-	-
	<i>M. ariommum</i>		+	-	-	-	-
	<i>M. cerninum</i>		+	+	-	-	-
	<i>M. erythrum</i>		+	-	-	-	-
	<i>M. macrolepidotum</i>		+	-	-	-	-
	<i>M. pappillosum</i>		+	+	+	-	-
	<i>M. rhothocicum</i>		+	-	-	-	-

Coastal Plain stream. Sweeney (1972) suggested that the preferred habitat is ponds, and that many individuals in streams may be expatriates or strays spawned in ponds. We have not been able to verify this statement, although most records from Maryland northward are from ponds and lakes. In the unglaciated Carolinas and Georgia, where natural ponds and lakes are few, nearly all collections are from small to large streams, although probably from their quiet, swampy margins. Collette (1962) listed the fishes and

the general relative density of rooted aquatic plants in the Bay Lakes of southeastern North Carolina. *E. chaetodon* was recorded in one lake and was questionably present in another, both of which were moderately vegetated; its apparent absence in the other lakes coincided with sparseness or lack of macrophytes. Louder (1962) stated that *E. chaetodon* seemed to occupy a very circumscribed (but unspecified) area in streams of the Lumber system, North Carolina. *Emmeacanthus gloriosus* and/or *E. obesus*

TABLE 1 (cont.)

Family Genus species	CHOWAN			DISMAL SWAMP	
	Meherrin and/or Nottoway			Blackwater	
	Piedmont	Fall Line	Coastal Plain	Coastal Plain	Coastal Plain
Ictaluridae					
<i>Ictalurus catus</i>	—	—	—	+	+
<i>I. natalis</i>	+	+	+	+	+
<i>I. nebulosus</i>	+	+	+	+	+
<i>I. platycephalus</i>	+	—	—	—	—
* <i>I. punctatus</i>	—	1	1	1	—
<i>Noturus gyrinus</i>	+	+	+	+	—
<i>N. insignis</i>	+	+	+	+	—
Amblyopsidae					
<i>Chologaster cornuta</i>	—	—	+	+	+
Aphredoderidae					
<i>Aphredoderus sayanus</i>	+	+	+	+	+
Cyprinodontidae					
<i>Fundulus diaphanus</i>	—	—	—	—	+
<i>F. lineolatus</i>	—	+	+	+	—
Poeciliidae					
<i>Gambusia affinis</i>	—	+	+	+	+
Centrarchidae					
<i>Acantharcus pomotis</i>	—	+	+	+	+
<i>Ambloplites caetfrons</i>	+	+	—	—	—
<i>Centrarchus macropterus</i>	+	+	+	+	+
<i>Chaenobryttus gulosus</i>	+	+	+	+	+
<i>Emmeacanthus chaetodon</i>	—	—	—	—	—
<i>E. gloriosus</i>	+	+	+	+	—
<i>E. obesus</i>	—	+	+	+	+
<i>Lepomis auritus</i>	+	+	+	+	—
* <i>L. cyanellus</i>	1	—	—	—	—
<i>L. gibbosus</i>	+	+	+	+	+
* <i>L. macrochirus</i>	1	1	1	1	1
* <i>L. microlophus</i>	—	—	—	—	1
* <i>Micropterus dolomieu</i>	1	1	1	—	—
<i>M. salmoides</i>	+	+	+	+	—
* <i>Pomoxis annularis</i>	1	1	1	—	—
<i>P. nigromaculatus</i>	+	+	+	+	+
Percidae					
<i>Etheostoma flabellare</i>	+	+	—	—	—
<i>E. fusiforme</i>	+	+	+	+	+
<i>E. olmstedii</i>	+	+	+	+	—
<i>E. vermicum</i>	+	+	+	+	—
<i>E. vitreum</i>	+	+	+	+	—
<i>Perca flavescens</i>	+	+	+	+	+
<i>Percina crassa roanoka</i>	+	+	—	+	—
<i>P. peltata</i>	+	+	+	+	—
<i>P. rex</i>	—	+	—	—	—
TOTALS (excluding introduced spp.)					
by column	51	49	43	41	25
by province	51	49		48	
total Chowan; Dismal			69		25
total native				70	

were reported in more than 90% of the North Carolina Commission collections of *E. chaetodon*, with *E. gloriosus* occurring slightly more often than *E. obesus*. *E. chaetodon* was usually taken in fewer numbers than *E. gloriosus* or *E. obesus*.

#### Distribution

*E. chaetodon* occurs on the Coastal Plain of the Atlantic slope from the lower Raritan drainage, New

Jersey to the upper St. Johns drainage, Florida. On the Gulf slope it inhabits Okefenokee Swamp and the upper Alapaha system of the Suwannee drainage, Georgia (Fig. 1; Records section). Bailey (1941) and Sweeney (1972) noted broad gaps in this range. Sweeney showed a hiatus consisting of the entire western Chesapeake Bay basin and south to the Neuse drainage of central North Carolina. He questioned the locality data with an old specimen supposedly from Beaufort, just south of the Neuse estuary. Collections

listed herein, mostly recent and none included by Sweeney (1972), show that *E. chaetodon* is in the Neuse, Tar, and Roanoke drainages.

Range disjunction and population localization of *E. chaetodon* were considered by Sweeney (1972) to have ecological and prehistorical geomorphic bases, rather than to be entirely the result of biased collection, and we agree.

Based on sampling effort in Virginia, there is little question that *E. chaetodon* is absent or quite rare in much of the seemingly suitable habitat in the southeastern part of that state.

The North Carolina Wildlife Resources Commission conducted an intensive statewide stream survey of fishes during the 1960's (summary by Ratledge et al. 1966; Menhinick et al. 1974). All watersheds were evenly sampled, with collection sites determined by a grid system, using similar ichthyocid techniques. The Coastal Plain fresh water region from the Tar drainage northward yielded but one record of *E. chaetodon* (Baker and Smith 1965) from some 250 collections. Southward, *E. chaetodon* was taken in 5 of 98 Coastal Plain Neuse drainage samples (Bayless and Smith 1962) and at 5 of 45 Northeast Cape Fear sites (Bayless 1963). Fifty-four collections from minor Coastal Plain drainages situated between the latter two drainages yielded no records (Davis and McCoy 1965). The species was collected at only 16 of some 145 Coastal Plain sites in the Cape Fear drainage (Loudner 1963). It appeared to approach a general distribution only in the Lumber system of the Pee Dee drainage, where it was taken at 26 of 117 stations (Loudner 1962).

The paucity of records of *E. chaetodon* for the extensive Coastal Plain region of Florida, Georgia, and outer South Carolina is most peculiar and not readily explained. Collette (1962) noted a similar distributional enigma of *Chologaster cornuta* in this region.

The absence or extirpation of *E. chaetodon* from many watercourses probably reflects submergences of coastal freshwaters by the sea during Pleistocene and Hypsithermal Holocene times, particularly in the western Chesapeake basin (Jenkins et al. 1972), undetected subtle ecological differences from occupied habitats, and possibly competition with other fishes such as small centrarchids.

### Southeastern Virginia Ichthyofauna

The freshwater ichthyofauna of southeastern Virginia, south of the James River drainage, is moderate in number of species, richer than those of drainages northward and smaller than those of several major more southern regions or drainages (Jenkins et al. 1972; Miller 1959; Ramsey 1965). The faunal lists (Table 1) are based on a wide survey, and probably very few species remain to be discovered and added to the total of 70.

The faunas of the Piedmont, Fall Line, and Coastal Plain sections of the Chowan system are similar in number of species, 51, 49, and 47, respectively. The tallies exclude several euryhaline fishes most of which enter only the Coastal Plain. The Piedmont section of the Chowan is drained by the upper Meherrin and Nottoway rivers. A major portion of the Chowan

Piedmont fauna consists, in addition to widespread species, of many forms characteristic of the rich and highly distinctive assemblage of the upper Roanoke drainage proper, in the Ridge and Valley, Blue Ridge, and upper Piedmont provinces. The latter fauna was treated by Jenkins et al. (1972) and Hambrick and Jenkins (unpublished).

Several upper Roanoke species extend in the Meherrin and Nottoway from the Piedmont down into, or are known in the Chowan only from, the Fall Line. The Fall Line is an ecotonal belt of varying width (Giles 1918; Thornbury 1965) containing stretches of gradient as high as or steeper than those on the outer Piedmont, and interspersed with or directly succeeded by low gradient Coastal Plain habitat. The Chowan Fall Line has only moderate gradient increments and apparently lacks falls. Meherrin River drops 0.9 m/km through the 12.9 km long Fall Line (Douglas Run to Metcalf Branch), and Nottoway River 1.0 m/km in 17.5 km (Buckskin Creek to Harris Swamp). The Meherrin on the outer Piedmont (from Totaro Creek) descends 0.4 m/km, and on the Coastal Plain (to N.C. State line) 0.3 m/km. Respective gradients of the Nottoway are 0.4 (from Waqua Creek) and 0.2 m/km. Some upland fishes in the Fall Line are *Exoglossum maxillingua*, *Nocomis leptoccephalus*, *N. raneys*, *Notropis albeolus*, *N. ardens*, *Hypentelium nigricans*, *Moxostoma cervinum*, *Ambloplites caucifrons*, *Etheostoma flabellare*, *Percina crassa roanoka*, *P. peltata*, and *P. rex*. The few of these species (Table 1) that penetrate downstream onto the Coastal Plain do so apparently only to a limited extent in the Meherrin and/or Nottoway, and some are localized in the middle section of the Blackwater branch of the Chowan Coastal Plain. Typical Coastal Plain species that extend into the Fall Line, but are known no farther upstream, are *Lepisosteus osseus*, *Umbra pygmaea*, *Notropis chalybaeus*, *Fundulus lineolatus*, *Gambusia affinis*, *Acantharcus pomotis*, and *Enneacanthus obesus*. The anadromous sea lamprey, *Petromyzon marinus*, was also taken only in the Coastal Plain and Fall Line. The two species now known in the Chowan only from the Fall Line are *Notropis bifrenatus* (taken in three collections from its only known Roanoke drainage locality, in part Jenkins and Zorach 1970) and *Percina rex* (an apparently declining endemic of the drainage, disjunct from the upper Roanoke population, Hambrick and Jenkins, unpublished).

The Piedmont fauna is augmented by the presence, just above the Fall Line, of forms more typical of and widespread on the Coastal Plain, as *Esox americanus*, *Noturus gyrinus*, *Aphredoderus sayanus*, *Centrarchus macropterus*, *Enneacanthus gloriosus*, *Pomoxis nigromaculatus*, *Etheostoma fusiforme*, and *E. serriferum*. Other widely distributed forms were collected in about equal relative frequencies on the outer Piedmont, Fall Line, and inner Coastal Plain, these being *Anguilla rostrata*, *Notropis analostanus*, *N. procerus*, *Moxostoma anisurum*, *Lepomis auritus*, *L. gibbosus*, and *Etheostoma olivaceum*. All of the latter group except *E. olivaceum* are also widespread in the upper Roanoke.

Since the Fall Line may combine Piedmont and Coastal Plain habitats, it might be expected, in a

small drainage basin, to harbor a significantly greater number of species than each adjoining province. This was not found in the Chowan. Elements of the typical faunas of the Piedmont and Coastal Plain tend to continue blending on each side of the Fall Line. This reflects a frequent paucity of discrete ecological boundaries and physical barriers (e.g. extensive riffles as an impediment to species of Coastal Plain pools) and the presence in a province of pockets of habitat similar to that on the opposite side of the Fall Line. Conversely, the Fall Line in other drainages, such as the Potomac, may be very narrow, include several stretches of extreme habitats as falls and cascades, and contain a reduced fauna.

Dismal Swamp has been long recognized as an interesting or unique biotic area (Andrews 1971; Whitehead 1972). However, the ichthyofauna of typical parts of the Swamp is depauperate, about 25 species compared with 47 in the Chowan Coastal Plain and 69 total of the Chowan. Some parts of the Swamp usually also support few aquatic beetle species (Matta 1973). A summary of 30 fish collections from waters closely adjacent to the Swamp (mostly from the Nansemond system, a tributary of the James River estuary) added about 15 native freshwater species additional to those listed herein from the Swamp. Of five fishes (*Moxostoma anisurum*, *Chologaster cornuta*, *Fundulus lineolatus*, *Micropterus s. salmoides*, *Etheostoma serripurum*) that apparently have a northern terminus of their Atlantic slope range just northwest of the Swamp, only *C. cornuta* seems established in the Swamp proper. At least four of the five extend into headwaters of the Blackwater branch of the Chowan.

Faunal differences among the watersheds of southeastern Virginia probably relate to many present factors or conditions extant during earlier stages of hydrographic development of the region. Matta (1973) suggested that low acidity (often pH 4-5) in Dismal Swamp, effected partly by accumulation of decomposition products, may be a major limiting factor for water beetles. The same is possibly true for fishes (Frey 1951; Collette 1962). The Coastal Plain Chowan also has poorly drained swamps but includes well defined natural surface channels with higher flow rates than in the Swamp. Thirteen pH values for the upper Blackwater range 6.0-6.8, usually 6.4-6.8. Habitats containing fishes in Dismal Swamp are rather homogeneous in several major factors. Overall the Chowan has an obvious vastly greater habitat diversity, for in addition to swamp water it includes riffles with stony substrates in the Piedmont and Fall Line and, for riverine fishes, large streams in all provinces. Extensive areas of current-swept sandy bottom are also present in the Chowan. Additionally the Chowan lies closer to rich faunal sources, the upper Roanoke and James drainages, than does Dismal Swamp. Dismal Swamp is youthful (Whitehead 1972); the Chowan had refugia during postglacial times of sea level rise. The application of a general tendency for larger areas, the Chowan in this case, to contain more species than smaller areas is also recognized.

Bonn, C. R. Gilbert, E. A. Lachner, R. S. Lee, E. F. Menhinick, J. A. Musick, M. D. Norman, W. M. Palmer, E. C. Raney, R. D. Ross, F. J. Schwartz, J. R. Sheridan, D. Smith, W. H. Tarplee, W. R. Whitworth, S. K. Whitt, and W. S. Woolcott. E. F. Sweeney permitted use of unpublished records plotted on his distribution map of *E. chaetodon*. N. M. Burkhead aided in plotting Virginia collection localities while supported by the Virginia Commission of Game and Inland Fisheries. Financial support for Zorach's collecting was by a grant from the Virginia Academy of Science. The manuscript was written during the tenure of NSF Grant BMS71-01372 A01 to Jenkins. We appreciate the advice given to us by R. S. Birdsong for improvement of the manuscript.

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*Acknowledgments:*—We gratefully thank those who provided access to collections or records: R. M. Bailey, R. S. Birdsong, R. I.

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Manuscript received July 14, 1975

## Observations on Limnetic Carbon Assimilation Rates in Mountain Lake, Virginia: A Correction

The first observations on carbon assimilation rates of limnetic phytoplankton in Mountain Lake Virginia were those of Simmons and Neff (1973). Obeng-Asamoah and Parker (1972), in completing a phytoplankton study of the lake, contributed additional information on inorganic carbon uptake by the limnetic phytoplankton community. More recently, in preparing a paper on the trophic state of Mountain Lake, Parker (in press) called attention to an error that had been made in computing the area under two of our original curves (Simmons and Neff 1973, Table 1). The areas were recomputed with a polar planimeter and have been corrected. The original and corrected values are presented in Table 1.

The corrections strengthen the data and do not detract from our original conclusion that Mountain Lake is more productive than other evidence would indicate. Moreover, the corrected values still lie above Rodhe's (1958) original upper boundary of 100 mg C/m<sup>2</sup>/day for oligotrophic lakes during the growing season. Perhaps a better viewpoint is to consider a more recent interpretation in which Rodhe (1969) proposes overlapping ranges in the autotrophic continuum rather than fixed "boundaries." He also envisions the transition from an oligotrophic to an eutrophic state being marked by an intermediate range of mesotrophy rather than by a given figure or limit. Using the values in his 1969 paper (Table 2), it would appear that Mountain Lake is certainly entering a

TABLE 2  
Transition in carbon assimilation rates from oligotrophic to eutrophic states (from Rodhe 1969)

AUTOTROPHY (phytoplankton)			
oligotrophic		eutrophic	
Mean rates in growing season	30-100	300-1,000	1,500-3,000 mg of C/m <sup>2</sup> /day
annual rates	7-25	75-250	350-700 g of C/m <sup>2</sup> /year

mesotrophic state. Additional nutrient input would most certainly alter the trophic equilibrium (Hutchinson 1973) and hasten the process to an eutrophic condition.

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TABLE 1  
Integrated assimilation rates of the phytoplankton in Mountain Lake, Virginia

Date	Original Value	Corrected Value
July 11, 1966	226.6 mg C/m <sup>2</sup> /day	296.7 mg C/m <sup>2</sup> /day
August 3, 1967	86.0 mg C/m <sup>2</sup> /day	218.7 mg C/m <sup>2</sup> /day

## News and Notes

### Mountain Lake Biological Station Outstanding Naturalist

The outstanding naturalist at the University of Virginia's Mt. Lake Biological Station was recognized on August 4, 1975. Mr. Joe Lankalis, a high school teacher from Coaldale, Pennsylvania, won first place. Second and third places went to Mr. Jim Ballard of Vienna, Virginia and Mr. Paul Marx of Chapel Hill, North Carolina. Winners received cash prizes and a certificate from the University made possible by a gift from Mr. Miles Horton, Jr. The event, to be held annually at the Biological Station, emphasizes the recognition and biology of plants and animals native to the Southern Appalachians. Over 30 contestants participated in the event.

### AAAS Project on the Handicapped in Science

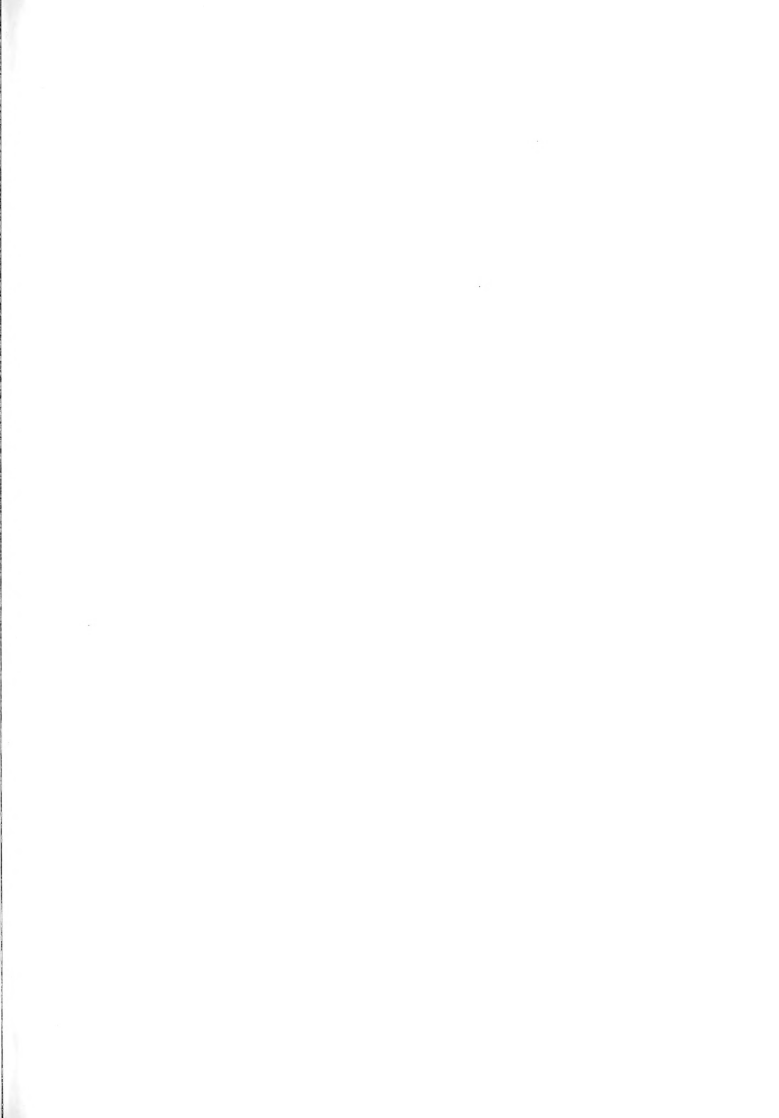
The American Association for the Advancement of Science has officially launched its Project for the Handicapped in Science. The purpose of this initial project, which is funded by the Rehabilitation Services Administration of the Department of Health, Education, and Welfare through the George Washington University Rehabilitation Research and Training Center is to identify and explore barriers obstructing the entry and full participation of physically disabled persons to education and employment op-

portunities in science. Specifically, the project will seek to examine and evaluate ways in which the scientific professional associations and organizations of and for the handicapped can contribute to equal opportunities in science careers.

In order to build an ongoing and realistic program, the AAAS needs the expert consultation of handicapped individuals who have experienced difficulties in receiving an education to be a scientist or in professional placement because of their handicap. *If you are a disabled scientist*, please identify yourself to Martha Redden, Director, Project on the Handicapped in Science, Office of Opportunities in Science, AAAS, 1776 Massachusetts Avenue, N. W., Washington, D. C. 20036. The project will not use, without permission, the names of individual scientists who respond.

Physically disabled scientists are encouraged to attend the Annual Meeting of the American Association for the Advancement of Science in Boston, February 18-24, 1976. The AAAS Office of Opportunities in Science is working with the AAAS meetings Office, Boston hotels, Rehabilitation Agency personnel and other interested people and groups in the Boston area to make the meeting fully accessible to people who are in wheelchairs, who have visual or auditory disabilities and those who need assistance because of other disabilities. For information and/or suggestions, please contact Martha Redden at the above address. Tel. (202) 467-4497.







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For review articles or those in some fields (e.g., history) an abstract may not be appropriate.

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Manuscript received March 26, 1975

Revised manuscript received September 19, 1975

## Concentration of Coliform Organisms at Freshwater Surfaces and their Transfer into the Atmosphere

**Abstract**—Preliminary investigations of several freshwater environments reveal that presumptive, confirmed and fecal coliform as well as other organisms are frequently at higher concentrations in the thin film of surface water than in sub-surface water. When bubbles of gas rise to the surfaces of these environments and burst, at least a part of the microbial community near the bubbles may be transferred to the atmosphere.

### Introduction

A considerable amount of literature has accumulated dealing with airborne microorganisms (i.e., bacteria, algae, fungi, and protozoa), while a second body of literature concerns microbial aerosols from various waste treatment processes (Adams and Spendlove 1970; Albrecht 1958; Goff, et al. 1973; Mahoney 1968; Randall and Ledbetter 1966). While it is recognized in the latter body of literature, though not in the former, that airborne microorganisms may in part come from a water-to-air transfer, there appears to be little attention paid to the mechanisms of concentration of microorganisms at the water surface and their transfer to the air above.

Hatcher and Parker (1974a,b,c) and Parker and Hatcher (1974) have established that significantly higher concentrations of bacteria, fungi, algae and various chemical substances frequently occur in the upper 20–100  $\mu\text{m}$  of freshwater environments, henceforth to be called the microlayer, than in subsurface water. There is excellent supporting evidence from marine microlayer studies as well as from freshwater laboratory studies to show that a major mechanism of concentration in microlayers is the selective adsorption of cells, particulates, and dissolved matter on the surfaces of rising bubbles of gas (i.e., adsorbable processes) (Blanchard and Parker, *in press*). The mechanism(s) of transfer of microorganisms, organic and inorganic matter adsorbed on the bubbles or already concentrated in freshwater microlayers also involve(s) the production of aquatic aerosols from

the energy of the bursting gas bubbles. Film drops or larger jet drops may be produced, depending on bubble size (Blanchard and Parker, *in press*; Blanchard and Syzdek 1972). Schlichting (1974) reported water-to-air transfer of algae by bursting bubbles in both algal cultures and aerated store aquaria and speculated on the probable spread of pathogenic bacteria and viruses by ejection from bursting bubbles in sewage aeration tanks, trickling filters, or fouled home aquaria.

In this paper we report field data demonstrating that (a) coliform bacteria and other microorganisms are often concentrated in freshwater microlayers, and (b) water-to-air transfer of microorganisms occurs in natural waters, especially those receiving artificial aeration.

### Materials and Methods

The aquatic environments used in this study included: a mesotrophic farm pond in Blacksburg; Clayton Lake, an impoundment of the New River approaching a eutrophic stage; and an unaerated waste oxidation pond in Merrimac, Virginia. These ecosystems have been described previously (Hatcher and Parker 1974a,b,c; Parker and Hatcher 1974). A fourth aquatic environment was Occoquan Reservoir near Manassas, Virginia, a highly eutrophic impoundment receiving treated waste from a number of upstream communities. Approximately 0.25 hectare of this reservoir receives continuous aeration immediately behind Occoquan Dam, the location of the aerosol studies reported here.

Surface microlayer water was collected both by a glass plate (Hatcher and Parker 1974b; Harvey and Burzell 1972) and a rotating drum (Hatcher and Parker 1974b; Harvey 1966). Subsurface water was collected by inverting a bottle at 10 cm depth until it filled with water.

Aerosols were collected on 100 mm Petri plates suspended 6 cm above the water on an aluminum rack attached to an inverted polystyrene ice chest. The inverted plates were exposed to both artificially aerated and nonaerated water surfaces for 15-minute periods, then sealed and returned to the laboratory for incubation.

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TABLE 1

Number of coliform bacteria per ml of drum-collected microlayer and subsurface (10 cm) water from 3 aquatic ecosystems determined via spread-plate on desoxycholate agar and incubation at 37°C up to 48 hours

Farm Pond, Blacksburg, Virginia				
Dates:	10-28-71	11-18-71	3-30-72	5-4-72
Microlayer	3,600	15	10	440
Subsurface	10	10	*	33
Claytor Lake, Virginia				
Dates:	10-7-71	11-4-71	11-23-71	5-11-72
Microlayer	300	25	*	330
Subsurface	50	65	20	80
Oxidation Pond, Merrimac, Virginia				
Dates:	9-23-71	10-14-71	4-20-72	5-18-72
Microlayer	40,000	60,000	1,800	50,000
Subsurface	20,000	20,000	1,200	*

\* No detectable growth

The following media were used:

- (1) the 15 tube Most Probable Number method for coliform bacteria; (APHA 1971)
- (2) Desoxycholate (Difco) and Eosin Methylene Blue (Difco) agar for presumptive coliform organisms;
- (3) Pond Water Agar [1 g Proteose Peptone (Difco), 1 g Yeast Extract (Difco), 500 ml filtered pond water, 500 ml distilled water, and 15 g agar (Difco)];
- (4) for algae, Chu 10. (Chu 1942)

### Results and Discussions

Table 1 illustrates that 10 out of 12 pairs of samples from three different aquatic environments and on different dates had greater numbers of presumptive coliform bacteria in the microlayer than in the subsurface. Table 2 illustrates that the microlayer contained greater numbers of presumptive coliforms on all three occasions and greater numbers of confirmed and fecal coliforms on two of three occasions. Table 3 shows for Occoquan Reservoir that, while confirmed coliform numbers were at least as great in the microlayer as in the subsurface water, fecal coliform numbers were higher in the microlayer at all three sites.

TABLE 2

Most Probable Numbers (MPN) of presumptive, confirmed, and fecal coliform bacteria per 100 ml of plate-collected microlayer and subsurface (10 cm) water from 3 aquatic ecosystems

Mountain Lake, Giles County, Virginia, 5-26-73			
Test:	Presumptive	Confirmed	Fecal
Microlayer	33	33	33
Subsurface	4	4	0
Mountain Lake 6-2-73			
Microlayer	79	23	2
Subsurface	49	33	23
Claytor Lake, Virginia 6-2-73			
Microlayer	≥ 2,400	≥ 2,400	1,600
Subsurface	79	79	79

TABLE 3

Most Probable Numbers (MPN) of confirmed and fecal coliforms per 100 ml of plate-collected microlayer and subsurface (10 cm) water from aerated and nonaerated sites at Occoquan Reservoir, Virginia, 8-22-73

Occoquan Reservoir, Virginia, 8-22-73						
Sites:	1 (aerated)		9 (nonaerated)		11 (nonaerated)	
	Confirmed	Fecal	Confirmed	Fecal	Confirmed	Fecal
Microlayer	1,600	79	≥ 2,400	1,600	2,400	1,600
Subsurface	540	21	≥ 2,400	920	2,400	920

In two separate experiments at Claytor Lake and Occoquan Reservoir in each of which 10 microlayer and subsurface samples were taken at arbitrarily selected locations, all data showed that the numbers of confirmed and fecal coliforms were at least as great in the microlayers as at 10 cm depth (Table 4). However, while the means of the 10 random samples, each from different locations on the lakes, also showed higher values for microlayers, standard deviations were extremely high, and the differences were not statistically significant.

The data in Table 5 confirm that large numbers of bacteria, fungi, algae, including coliform organisms, are readily ejected into the atmosphere by bursting air bubbles at the aerated surface of Occoquan Reservoir. The right column shows an estimate of the total daily production of microbial aerosols from this reservoir, which possesses approximately 0.25 hectare of artificially aerated surface. A 60-minute aerosol experiment, carried out upstream in a nonaerated tributary of Occoquan Reservoir known to possess anaerobic muds, produced a small number of colonies on agar plates. These consisted of coliform and noncoliform bacteria, and one green alga. However, as the gas bubbles (probably methane) in this stretch of the river were produced in a nonpredictable pattern, it was purely a matter of chance that the polystyrene apparatus with plates totalling about 800 cm<sup>2</sup> of agar surface was poised over an area of bursting bubbles. Wide variation in production of aerosols

TABLE 4

Means ( $\bar{x}$ ) and standard deviations (s) for Most Probable Numbers of confirmed and fecal coliforms per 100 ml of plate-collected microlayer and subsurface (10 cm) water from 10 nonaerated sites picked randomly at Claytor Lake (8-4-73) and Occoquan Reservoir (7-31-73), Virginia (values > 10 rounded to whole numbers)

	Confirmed			Fecal		
	Range	$\bar{x}$	s	Range	$\bar{x}$	s
<u>Claytor Lake</u>						
Microlayer	0-49	14	19	0-12	1.7	3.9
Subsurface	0-33	7.3	12	0-10	1.4	3.3
<u>Occoquan Res.</u>						
Microlayer	0-1600	221	512	0-350	40	110
Subsurface	0-32	6.2	13	0-6	0.6	1.9

TABLE 5

Number of culturable microorganisms recovered on various agar media 6 cm above the aerated surface of Occoquan Reservoir, Virginia 7-31-73 (See text for details)

	Colonies/hr/plate	$\bar{x} \pm 0.25$ hectare/ day $\times 10^6$	
		$\bar{x}$	
Eosin Methylene Blue Agar (total coliform)	24, 32, 32	29.3	22.32
Pond Water Agar (total bacteria)	240, 180, 160	193.3	147.84
Chu 10 (algae, a & fungi, f)	48f, 14a; 48f, 32a; 46f, 24.7a 42f, 28a		35.28f, 18.96a

over an area of water is also implied by the standard deviations given in Table 4.

Our data reveal that coliform organisms are frequently concentrated in freshwater microlayers, sometimes reaching densities which are one or more orders of magnitude greater than those of the subsurface water. These findings are consistent with our more extensive data on algae, fungi, total bacteria, inorganic and organic substances (Hatcher and Parker 1974a,b,c; Parker and Hatcher 1974). Though it has not yet been proven, viruses may also be concentrated in surface freshwater microlayers. These data further show that microorganisms are apparently transferred from microlayer to atmosphere by bursting bubbles, the mechanism of which has been discussed in detail (Blanchard and Parker, *in press*; Blanchard and Syzdek 1972). Our results from Occoquan Reservoir indicate that, while the water-to-air transfer of microorganisms is accelerated by artificial aeration, at least some un aerated aquatic environments may produce gas bubbles which may cause microbial aerosols. Because of the observed heterogeneity of surface slicks, it is not surprising that there are great variations in microlayer composition within a single aquatic environment.

A reasonable probability exists that water-borne pathogens may constitute a part of the total aerosol, as has been shown for various waste treatment processes (Adams and Spendlove 1970; Albrecht 1958; Goff, et al. 1973; Mahoney 1968; Randall and Ledbetter 1966). This probability becomes even greater when one considers the evidence that enteric path-

ogens, such as *Salmonella typhimurium* and other coliform organisms may multiply in organic-rich river water (EPA 1972).

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Manuscript received April 14, 1975  
 Revised manuscript received October 6, 1975

## Population Density and Attitudes Toward Population Control

**Abstract**—Does population density influence attitudes toward population control or the tendency to perceive population problems somewhat abstractly? In the first study the Population Opinion Poll (POP), an attitude scale designed to measure attitudes toward population control, was administered to 155 community college students from three regions of Virginia differing greatly in population density. Estimates of the extent to which subjects perceived population problems abstractly were obtained by analyzing a few POP items known collectively as the abstraction index. The second study was much like the first except that subjects were also measured on socio-economic status and data were obtained from 248 subjects representing four schools. Results showed that population density had no effect on POP scores or on abstraction index scores in either study.

It seems reasonable to think that a person's attitude toward the environment would be influenced by the kind of environment in which he lived. On the other hand, we are told that "It is a strange fact in the history of psychology that relatively little effort has been devoted directly to finding out how, or even if, people perceive the full-scale environments within which they live" (Ittelson, et al. 1974, p. 102).

A more specific issue is that of the perception of population density and its effect on attitudes toward population control. Barnett (1972 a) found that city size was unrelated to attitudes toward population control, where city size was divided into six categories ranging from under 2,500 to over 1,000,000.

Barnett (1972 b) also found that a rural ideal, defined as "the strong desire to live in areas of low population density" (p. 235), is slightly more likely to characterize those living in less populated areas, and that in the South those with a rural ideal were less likely to favor population control than those with an urban ideal. Sweet (1974) found that the standardized fertility rate was higher for rural than for urban subjects. Since the number of expected children is positively related to the actual number of children born (Westoff, Mishler, & Kelly 1959; Westoff, et al. 1963) and since Fischer (1972) and McCutcheon (1974) have shown that number of expected children is negatively related to attitudes favoring population con-

trol, then Sweet's data suggest that individuals living in sparsely populated areas would be less likely to favor population control.

On the other hand, McCutcheon and Vick (Note) have shown that black college students in a moderately populated area are more favorably inclined toward population control than black students living in a densely populated area. It remains to be seen if population density has any effect on the attitudes of predominantly white subjects toward population control.

A second issue examined here is that of the abstract perception of the population problem and its possible relationship to population density. Results of several studies (Barnett 1970; Buckhout 1972; Crawford 1973; Fischer 1971; McCutcheon & Vick, Note ) show that Americans are generally aware that a population problem exists, but are reluctant to accept personal responsibility for it. There is practically no evidence linking this tendency to perceive the population problem abstractly, with the population density of respondents. Barnett (1970) has demonstrated that the population problem is perceived abstractly in a small, isolated community, and McCutcheon and Vick (Note) have done the same in a densely populated metropolitan area, but the measures used were not directly comparable. The purpose of the present studies is to compare college students from areas of different population density on attitudes toward population control and the tendency to perceive the population problem abstractly.

### Study 1

**Methods:** The subjects were 155 college students from Virginia, 58 from a college located in Fairfax County and designated as NVCC, 56 from a college in Frederick County designated LFCC and 41 from a school in Alleghany County designated as DLCC. The overwhelming majority of these subjects resided within a few miles of their respective colleges. In 1970 the populations per square mile in these three counties were 1,140.4, 71.3, and 28.1, respectively. The samples were not significantly different with respect to age or number of children expected (see Table 1). Subjects were classified by political preference as either Democrats, Republicans or having no party

preferences. A chi-square analysis revealed a significant difference among groups ( $\chi^2 = 9.79$ ,  $df = 4$ ,  $P < .05$ ). Republicans were underrepresented at NVCC and overrepresented at LFCC. A trichotomy was established for religious preference, with the categories being Protestant, Catholic, and no preference. A chi-square test revealed a significant difference among groups ( $\chi^2 = 9.89$ ,  $df = 4$ ,  $P < .05$ ). Further inspection showed that those with no expressed preference were underrepresented at DLCC and overrepresented at LFCC.

All subjects filled out the Population Opinion Poll (POP), a thirty-item, Likert-type, attitude scale designed to measure attitudes toward population control (McCutcheon 1974). High scores represent attitudes favorable to population control. The POP was administered to various psychology classes by the regular class instructor. The first page asked for much of the data mentioned in the previous section. Abstraction index scores were computed by comparing the scores from four subjectively chosen POP items acknowledging the fact that there is a population problem with four subjectively chosen items suggesting that action be taken (McCutcheon & Vick, Note). High positive scores indicate a tendency to view the population problem abstractly.

**Results:** *F*-test comparisons of POP attitude scores and abstraction index scores for the three samples showed no significant differences. Table 1 shows the mean scores.

McCutcheon (1974) has shown no significant difference on POP scores among Republicans, Democrats, and those with no party preference, although Republicans scored about ten points below the other two groups. If the three groups had been equated on political preference the most likely result would have been a one or two point reduction in the mean for NVCC and a one or two point increase in the mean for LFCC. McCutcheon (1974) has also demonstrated a nonsignificant difference among Protestants, Catholics and those with no religious preference, although the latter group averaged about nine points higher. Had the groups been equated on religious preference the most likely result would have been no more than a one or two point increase for DLCC and a similar increase for LFCC. The end result would most likely have been that attitudinal differences would remain nonsignificant. Abstraction index scores were found to be unrelated to age in all three samples. There was no significant difference on index scores among individuals differing on religious and political preference.

It is tempting to conclude that population density has no effect either on attitudes of community college students toward population control or on the tendency to view population problems abstractly. On the other hand, the difference on POP scores approached the .05 significance level, and given the possibility that sample differences in religious preference might have widened the gap in means, it is at least remotely possible that population density is an important determinant of population-related attitudes. In addition, social class was not controlled in Study One, so for these reasons it was decided to conduct a second study.

TABLE 1  
Mean Scores on Four Variables Categorized by Study

Group	POP	Abstraction Index	Age	No. Children Expected
Study 1				
DLCC	150.29	6.97	21.61	2.42
LFCC	140.21	6.14	23.68	2.02
NVCC	149.09	5.67	23.59	2.30
Study 2				
DLCC	152.62	5.31	19.73*	1.58
LFCC	144.39	5.45	24.69	2.03
GCC	145.04	6.53	23.02	1.66
NVCC	149.11	5.94	25.55	2.06

\*  $P < .02$

### Study 2

**Method:** The subjects were 248 community college students from the state of Virginia, 64 from NVCC, 85 from LFCC, 26 from DLCC, and 73 from a school located near the border of Spotsylvania and Stafford Counties designated as GCC. The populations per square mile in these two counties were 40.2 and 91.1 respectively. Following a significant *F*-test a series of *t*-tests revealed that the sample from DLCC was significantly younger than the others ( $P < .02$ ). The samples did not differ significantly with respect to number of children expected or political party preference. Subjects did differ on religious preference, however ( $\chi^2 = 27.64$ ,  $df = 6$ ,  $P < .005$ ), with DLCC reporting fewer subjects in the no preference category. "Highest educational level completed by father" was used as a measure of socioeconomic status. Means were 13.25, 11.65, 11.90, and 12.31 respectively ( $F = 2.34$ ,  $df = 3/215$ , *NS*).

**Results:** *F*-test comparisons of POP scores and abstraction index scores revealed no significant differences. Table 1 shows the mean scores.

Since age has previously been found to be nonsignificantly but negatively related to POP scores the net effect of an attempt to equate subjects on age should result either in no change at all or in a slight reduction in the POP score mean for DLCC. This would further reduce the probability of obtaining a significant POP score difference. On the other hand, the fact that DLCC subjects were less likely to report no religious preference would be likely to raise scores slightly if an attempt were made to equate subjects on religious preference. The net effect would not be likely to change the nonsignificant results obtained in the second study. Since the results of the first study showed that abstraction index scores were unrelated to age, religious preference, and political party preference, and results from the second study indicate no significant relationship between socioeconomic status and abstraction index scores ( $r = -.01$ ,  $df = 58$ ), it seems unlikely that population density has any effect on the latter.

### Conclusions

It would appear that community college students, at least, do not form their attitudes toward population control by looking at the population den-

sity of the environment in which they live. Perhaps they form population-related attitudes primarily on the basis of family background variables, coupled with what they read or hear about the topic. Would attempts to persuade people that population control is necessary, be successful if population density was stressed? Should persuasive communication emphasize a comparison of the population changes occurring in regions of rapidly expanding population? The present research, employing a fairly broad sample, suggests that attitudes toward population control are not influenced by population density. Is this because people have generally failed to link conceptually an increasing population with its accompanying problems, or because having done so, they remain unimpressed? Data generated from the use of the abstraction index suggest the former, but in the main the answer would seem to necessitate further research.

*Acknowledgments*—Assistance from the following people is gratefully acknowledged: Ann Bice, Jerome Friga, Fred Knobloch and Loretta Matyas.

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Manuscript received June 24, 1975

Revised manuscript received Oct. 14, 1975

## Phytoplankton Species Composition in the Lafayette River Estuary, Norfolk, Virginia, 1971-1972

**Abstract**—Water bottle samples were taken twice a month from two sites in the Lafayette River, from March 1971 through February 1972. Phytoplankton were identified to species level, and a volume of the sample was counted to determine concentrations in cells per liter.

The diatom *Skeletonema costatum* dominated the population near the mouth of the river through much of the year. The species was co-dominant with flagellate forms, such as *Gymnodinium*, *Amphidinium*, and *Thalassiomonas*, in the reduced salinity of the upstream station. Forms of *Cyclotella* and *Melosira* were believed to be important as well. The general successional pattern was bimodal with high production in spring and summer, but the population varied in species composition and in total numbers between the two sites.

### Introduction

The Lafayette River (Fig. 1) was selected as a suitable site for study because of its accessibility and compactness. It is not, in fact, a true river, but represents an elongated estuary under tidal influence throughout its length. The fresh water input of the river is from rainfall and runoff from the city of Norfolk.

Much of the shore is developed residentially, with land fill fairly common in new and old construction. Several marinas are located either on the waterway or in one of the inlets off the main portion of the river. There is a sewage treatment plant of 19-31 million gallons per day (Montgomery 1972) near the mouth of the river. The mean depth is 1.1 meter (Montgomery 1972), and a channel with 2 meter controlling depth extends from the Elizabeth River channel to the Granby Street Bridge.

Little work has been done on the phytoplankton of the Lafayette River (Marshall 1968 and Golub 1972). More work has been done in the Elizabeth River and Hampton Roads by Marshall (1967a, 1967b, 1968) and in the Chesapeake Bay by Fogg (1965), Mulford (1963), Pattern, et al. (1963), and Whaley and Taylor (1968). Several older studies such as those by Cowles (1930) and Wolfe, et al. (1926) were also done in the Chesapeake Bay. Recently, chemical and physical data have been obtained by Montgomery (1972) and White (1971) supplementing work done by Pritchard (1952) on the James River Basin.

The purpose of the study was to determine the composition and successional patterns of the phytoplankton in the Lafayette River and to correlate them with environmental parameters.

### Methods and Materials

Samples were taken with a Kemmerer water bottle twice a month at the same time of day from March, 1971 through February, 1972, from a boat in mid-channel. Water was obtained from one meter below the surface and one meter above the bottom at each of two sites (Fig. 1). 500 ml of each sample was preserved immediately with 40 ml of 10% buffered formalin. Water temperature was obtained concurrently with a reversing thermometer, and the salinity of each station was determined with a G&M Manufacturing hydrometer-type field salinity kit. An indication of turbidity was obtained by use of a Secchi disk. The 500 ml phytoplankton sample was allowed to settle at the laboratory and the supernatant siphoned to a final concentration of 40 ml. An aliquot of 0.125 ml was settled in a Zeiss chamber and counted using a Zeiss Inverted Plankton Counting microscope at 350x. These counts were multiplied by 658 to obtain counts in cells/liter. Nutrient data which were used in the evaluation were obtained from Montgomery (1972 and pers. comm.) who was sampling for nitrate and phosphate levels during the same time period at sites nearby.

Station 1 (Fig. 1) was located near the mouth of the estuary. The water depth in the channel at this site ranged from 4.5 to 5.75 m. The water depth on each side of the channel was approximately one meter and the bottom composed of fine, dark mud overlying sand.

Station 2 was located at the upper end of the channel, and depth at this site was 3.9 to 5.5 m. Tidal flow and bottom composition were approximately the same as those at station 1, although the water was generally a good deal more turbid.

### Results

The relative numbers of major species of phytoplankton collected in the Lafayette River are given in Fig. 2. 207 species were noted from both stations: 170 at station 1 and 154 at station 2. There were 124 species common to both stations. A com-

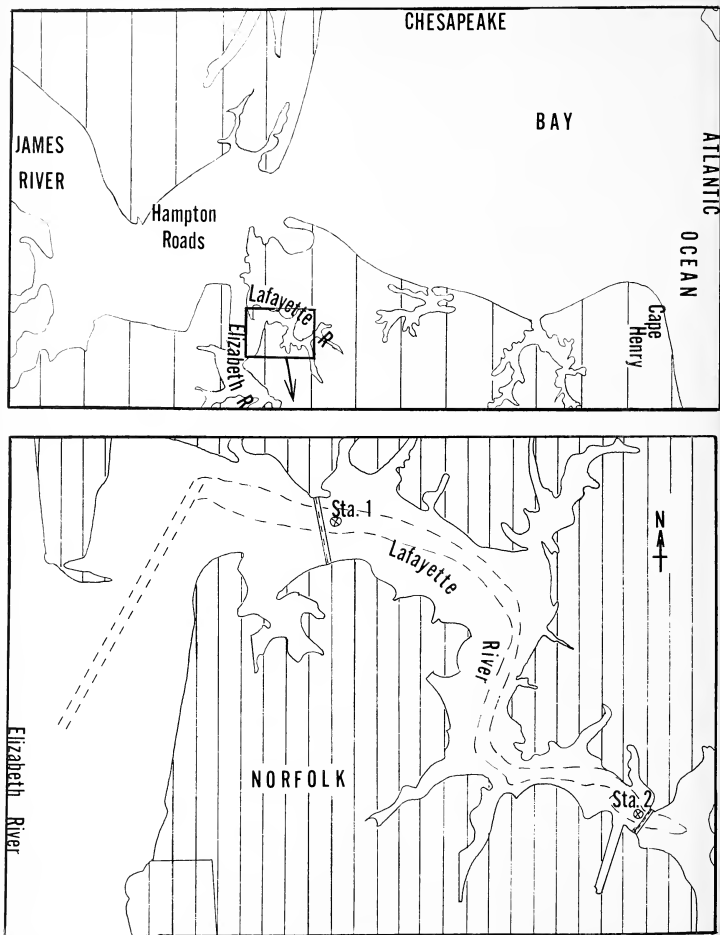


FIG. 1—The Lafayette River and vicinity showing sampling sites 1 and 2.

plete species list is available from the author on request. Diatoms were dominant at both stations. Phytoflagellates were of greater importance at the upstream station 2 than at station 1. The single most important species was *Skeletonema costatum*. Station 2 had numerically larger populations, and they tended to fluctuate more radically than those at station 1 (Fig. 3). A modified bimodal successional pattern was common to both stations. Concurrent mean water temperature and salinity data are presented in Fig. 4. Station 2 was 1‰ to 2‰ lower in salinity and averaged 0.72°C warmer during the year.

### Discussion

Of the major diatom species noted, *Skeletonema costatum*, *Coscinosira polychorda*, and *Rhizosolenia fragilissima* are considered by Cupp (1943) as neritic north-temperate while *Thalassiosira rotula*, *Asterionella japonica* and *Cerataulina bergonii* are neritic-south temperate, and *Thalassiosira nordenskioldii* and *Nitzschia seriata* are considered boreal or arctic species. Species of lesser significance were the oceanic species *Chaetoceros decipiens*, *Corethron hystrix* and *Rhizosolenia calcar avis* and the brackish or littoral species *Cyclotella striata*, *Litnophora* sp., and *Nit-*

	STATION 1												STATION 2											
DIATOMS	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
ASTERIONELLA JAPONICA	1	0						0	0	0	0		1	0								0		
CERATAULINA BERGONII	1								0				0					0				0		
CHAETOCEROS DECIPIENS				1	0												0							
COSCINODISCUS BALTICUS											0	0											1	2
COSCINODISCUS SPP.	0	0	0	0				0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
COSCINOSIRA POLYCHORDA	1	1	0		2								0	1										
CYCLOTELLA GLOMERATA					0	2	0				1						0	3	0				0	
CYCLOTELLA MELOSIROIDES				5	1	1	0	0	0	0	0	1			3	0		0	0	0		0	0	
CYCLOTELLA SP. 1				0	2							0											0	
CYCLOTELLA SP. 2				0	2	1	3	1	0	0							0	1	2	1	0			
CYCLOTELLA SP. 3					0	1	0	0	0	0							2	2	0	0	0			
LEPTOCYLINDRUS DANICUS	1	1		0							0	0	0	0								0		
MELOSIRA FENNOSKANDICA				5	0		0	0							1		0	0	0					
MELOSIRA GRANULATA				1		0	0	0	0	0	0	0					0	0	0	0				
MELOSIRA SULCATA				1		0	0	1	1	0	0				0		0	1	1	1		0		
NAVICULA SP.		1	0	0	0	0					0	0		0	0	0				0	0	0	0	
NITZSCHIA CLOSTERIUM	0	0	0	0	0	1	0	0	0	0	0	0		0	0	0	2	0	1	0	0	0		
RHIZOSOLENIA FRAGILISSIMA	1				0						0	0						0				0	0	
SKELETONEMA COSTATUM	5	3	0	0	4	4	2	1	1	1	0	5	4	5	0	2	0	2	0	0	1	1	4	
THALASSIOSIRA AESTIVALIS					2	4					1						2	1						
THALASSIOSIRA NORDENSKIOLDII	0	1		2	1	1	0	0		0	0	0	0	0	0	1	2	0			0	0		
THALASSIOSIRA ROTULA	1			0									0											
PHYTOFLAGELLATES																								
AMPHIDINIUM KLEBSI		2	1					0						1					0					
AMPHIDINIUM SP.			0					0	0	0	0	0		3			0	0			4	0	0	
CHLAMYDOMONAS SP.	0	0	0	0			0						2	0	0	0			0	0	0	0		
CRYPTOMONAS SP.			0	0	0	0	1	0	0	0	0	0						0	0		0	0	0	
EUTREPTIA MARINA			0	0	0	0	1	0	0	0	0	0		0	2	0	0	0	1	0	0	1	0	
EXUVIELLA APORA					0	0	2	2	0	0							0	0	0	3	2	1	0	
EXUVIELLA MARINA	0				0												3					0	0	
GYMNODINIUM SIMPLEX			0			0	0	0	0	0							1	0						
GYMNODINIUM SPLENDENS				4	0	1	0										4	0	0					
GYMNODINIUM SP. 1			0	1		0								0	0	1					0	0		
GYMNODINIUM SP. 2				0	0	0	1	0	0					0	1	0	0	1	0					
GYMNODINIUM SP. 3					0	0	0										1	1	0					
PERIDINIUM SP.	0	0	0		0	0	1	0					0	0	0	1	1	0	0	0		0		
THALASSIOMONAS SP.																	0	0	0	0	1			
ATHECATE DINOFLLAGELLATE					3	3											0	4	0					
PHYTOFLAGELLATE SP. 1								1	1	0	0		0	2	1					1	0	0	0	
PHYTOFLAGELLATE SP. 2	1		2	1				0	1	1	0		3	5	3	5			0	0	4	3	1	
CYANOPHYCEAE																								
ENTOPHYSALES DEUSTA								0	0	0	0							0	0	1			0	
MERISMOPEDIA TENUISSIMA	1	1							0	0				1	0	0				1	1		0	
OSCELLITRATOR SPP.				2		1	0	0	1								0	1	0	0	0		0	
SPIRULINA SUBSALSA				1	0	1											1	0						

FIG. 2.—List of important species at each station, showing relative numbers. 0—presence; 1—1 to  $10 \times 10^4$ ; 2—10 to  $25 \times 10^4$ ; 3—25 to  $50 \times 10^4$ ; 4—50 to  $100 \times 10^4$ ; 5— $100 \times 10^4$  +.

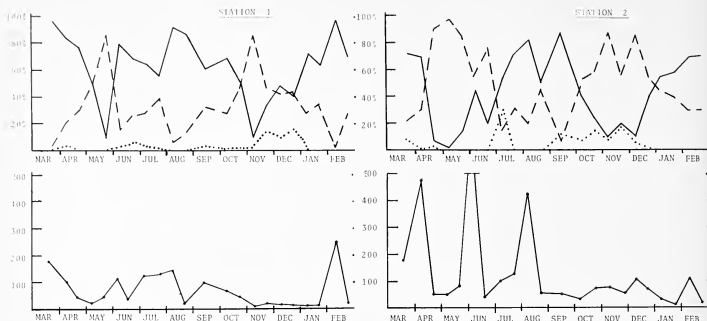


FIG. 3.—Total numbers of phytoplankton  $\times 10^4$  (lower) and percent of diatom (solid line), dinoflagellates (broken line) and blue-green algae (dotted line) present in counts at each station.

*zschia longissima*. A few fresh water species, *Asterionella formosa* and *Gyrosigma spencerii*, and the Chlorophyceans *Scenedesmus quadricauda* and *Staurostrum aspinosa* were apparently introduced from the Elizabeth River flora and were present in low numbers in the fall and winter.

The major flagellate forms, *Amphidinium klebsi*, *Gymnodinium splendens*, *Thalassiomonas* sp. and several unidentified phytoflagellate species are considered brackish water species (Hulburt 1965, 1965; Parke 1949).

Notable in its absence was any form of *Ceratium*, which had been found by most workers in the Chesapeake Bay.

Although diatom species appeared to dominate the mouth of the river, at station 2 diatom species were codominant with flagellate forms during much of the year. These forms included *Amphidinium klebsi*, *Gymnodinium splendens*, *Eutreptia marina*, an atecate form of what was considered to be *Gymnodinium*, and several species of Chrysomonad-type flagellates. In addition, there were Cyanophyceans, including *Merismopedia tenuissima* and *Entophysalis (?) deusta*, during the fall months.

The dominant diatom was *Skeletonema costatum*. Patten, et al. (1963) and Marshall (1967b) have noted that this is the dominant species of the coastal region of this portion of the East coast. The success of this species may be attributed to extreme adaptability to local environmental conditions, possible seasonal varieties and a meroplanktonic life cycle (Braarud 1962). Station 1 (Fig. 1) was frequently dominated by pulses of *S. costatum*, and the species formed an important member of the population at station 2. Dominance was often shared with flagellate forms at the latter station.

The general pattern of succession followed in the Lafayette River was a modified bi-modal one. The first maximum taking place in the spring was com-

posed primarily of diatoms at both stations, although flagellate forms were important at station 2 (Fig. 2). This pulse decreased in May. The second maximum was actually a series of pulses which took place during the summer. This was at first composed primarily of diatoms, but as the waters grew warmer the population became increasingly dominated by phytoflagellate forms, especially at upstream station 2. Fall and winter demonstrated decreasing abundance at both stations and a slow transition from flagellate to diatom dominance. Cyanophyceans were present at both stations during the fall in fairly large numbers. Small pulses were common in early winter, but the total numbers dropped during January. Wolfe et al. (1926), Marshall (1967 b), and Whaley and Taylor (1968) have noted similar spring increases in Cyanophyceans from February through March from the low numbers present in winter populations.

January had the lowest counts for the entire year, although nutrient levels were higher than those considered normal for the Chesapeake Bay (Montgomery 1972). They could be considered sufficiently high to support a far larger population. The principal species present at both stations were the diatoms *Coscinodiscus balticus*, *Coscinodiscus* sp., *Cyclotella* sp., and *Skeletonema costatum*.

The increase in water temperature (Fig. 4) and sunlight values (USCOMM-NOAA, 1971) appeared to encourage phytoplankton growth. Cell numbers per liter reached  $2 \times 10^6$  at station 1 and  $0.8 \times 10^6$  at stations 2. Both stations were dominated by *S. costatum*. After the brief pulse total numbers of *S. costatum* dropped to  $0.15-0.25 \times 10^6$  at both stations until March when at station 1 a second pulse of bloom proportions occurred. Station 2 reached  $2.8 \times 10^6$  cells per liter during the first part of April. Other species present, principally *Rhizosolenia fragilissima*, *Coscinosira polychorda* and *Asterionella japonica* at station 1, and *Peridinium* sp. and other phytoflagel-

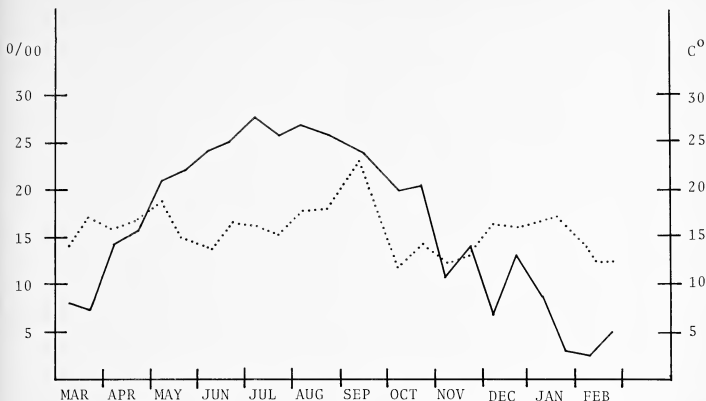


FIG. 4—Average surface values by month of temperature (C°), solid line, and salinity (‰), dotted line, from March, 1971 through February, 1972 in the Lafayette River, Norfolk, Virginia.

late species at station 2 did not increase during this time.

Following the April peak, numbers were low ( $0.2 \times 10^6$ ) throughout the river, and *S. costatum* was replaced in importance by other species, but none of these ever obtained a dominant status (Fig. 2). These were *Coscinodiscus* sp., *Synedra ulna*, and *Amphidinium klebsi*. Phytoflagellate sp. 2, a monad form, was present in concentrations approximating each of the other three species.

Total concentrations of cells increased in June, as the water temperatures reached 20°C. Nutrient levels at this time were sufficient to support a large population (Montgomery 1972). The nitrate levels were much the same as they had been the preceding month. This may indicate that water temperature was, with light intensity and duration, a major factor in the summer increase.

Four species began to increase at the same time: *Cyclotella melosiroides* and *Melosira fennoscandica*(?) at station 1, and *Exuviella marina* and an unidentified phytoflagellate species at station 2. Secondary species *S. costatum* and *Cyclotella* sp. at station 1 and an athecate dinoflagellate at station 2 increased slightly toward the end of the month.

Numbers were  $1.5 \times 10^6$  and  $1.3 \times 10^6$  at stations 1 and 2 respectively as temperatures reached a yearly maximum in July and *S. costatum* with *Gymnodinium splendens* were dominant at both stations. Diatom species were still of primary importance at station 1: *Coscinosira polychorda*, *Cyclotella* spp., and *Thalassiosira aestivalis* were prominent. The latter two species formed an important segment of the station 2 secondary population together with *Nitzschia closter-*

*ium*, but *S. costatum* was less important than it was at station 1.

A peak was reached in early August of  $2 \times 10^6$  cells per liter at station 1 and  $3.5 \times 10^6$  cells per liter at station 2. *S. costatum* bloomed at both stations in the first part of August and caused the river to be dominated by diatoms for a short time. Other diatom species also increased during this time, notably *Cyclotella glomerata*, *Cyclotella* sp., and *Coscinodiscus aestivalis*. One flagellate species, *Eutreptia marina* also increased in numbers.

The bloom was short lived, as nitrate levels dropped (Montgomery 1972). The water temperature was decreasing, and oxygen levels declined to the low for the year (Purcell 1973). Total numbers of cells and species variety dropped as well, but *Cyclotella* sp. and *S. costatum* continued to dominate both stations. These were replaced in importance in October by *Exuviella apora* at station 2 and *Melosira sulcata* at station 1. Phytoflagellate species 2 was also prominent at both stations in the beginning of November and replaced *E. apora* and *M. sulcata* as dominant species, although these two remained numerous and *S. costatum* increased slightly. The close of the year saw *S. costatum* dominating station 1 and *Amphidinium* sp. dominant at station 2. Phytoflagellate sp. 2 and *Olisthodiscus* sp. were also important at the up river stations.

The species composition of the Lafayette River is similar to that noted by Wolfe, et al. (1926) and Whaley and Taylor (1968) in the Chesapeake Bay. It is also similar to that of the Elizabeth River region (Marshall 1967b). It is interesting to note that the differences in species composition between the two

stations is similar to that noted by Wolfe, et al. (1926) and Cowles (1930) between stations at the mouth and those near the head of Chesapeake Bay.

### Conclusion

While many of the important species were common to both stations, there were population and compositional differences between them at any given time. Station 2 generally had higher concentrations of phytoplankton and a greater amplitude of seasonal pulse than station 1. There appeared to be a shift in population composition from that of primarily diatom species at station 1 to a combination of diatom and phytoflagellate species at station 2. Given these differences, there is a yearly pattern of succession which is shared by both stations. While the species which make up the population at each site differ, as does the size of the population, the modified bimodal pattern of spring and summer peaks of production with declining numbers in the fall and winter is demonstrated at both sites. For the most part, species which were common in the Chesapeake Bay dominated the Lafayette River as well. An exception was *Melosira* sp., which was noted in the Lafayette River in significant numbers, but which had not been mentioned as prominent in earlier reports.

**Acknowledgments**—The author wishes to thank the Norfolk branch of the Army Corps of Engineers for supplying a boat and crew to assist in sampling. Thanks are also given to Dr. Harold Marshall for his valuable assistance with the project. The research for this paper was completed as part of the requirements for a Master of Science degree at Old Dominion University, Norfolk, Virginia.

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Manuscript received August 18, 1975  
Revised manuscript received November 7, 1975

## Dimorphism in the Red-Backed Salamander *Plethodon cinereus* (Green) at Mountain Lake, Virginia

**Abstract**—A five mile north-south cline located in Giles County, Virginia USA, in which the frequency of the unstriped morph of the salamander *Plethodon cinereus* decreases from 0.13 to 0.00, is described and analyzed. There is no correlation between the frequency of unstriped and altitude, type of vegetation, surface moisture, type of cover preferred, or the season of sampling. Unstriped salamanders were found at higher frequencies in areas with a lower average daily temperature and less fluctuation between daily high and low temperature extremes. Analysis of egg clutches tends to support the hypothesis that the striped phenotype is dominant.

### Introduction

Polymorphism is the occurrence together in the same locality of two or more discontinuous forms of a species in such proportions that the rarest of them cannot be maintained merely by recurrent mutation (Ford 1940). *Plethodon cinereus* (Family Plethodontidae) exhibits such a polymorphism in its dorsal coloration, having a striped form ("red-backed") and an unstriped form ("lead-backed"). Striped individuals have a dorsal line from head to tail. This stripe may vary in color from bright red to white, while the unstriped form has a uniform brownish-black color (Hertzler 1958).

Geographic variations in the frequency of striping occur throughout the range. Highton (1962) reports that the unstriped form is scarce in parts of Canada, New England, eastern New York, Georgia, Arkansas and Oklahoma and is known to be abundant in only a few scattered areas in Illinois, Ohio, New York, Maryland, and localities near Ottawa and Montreal. Both color forms occur through most of the range with the striped form usually being more plentiful. In some areas the local variation is striking, affording the opportunity to study factors responsible for maintaining the dimorphism.

Little is known about factors that influence the frequency of the striped phases. Over a distance of five miles, the proportion of unstriped animals on Potts Mtn., Giles Co., Virginia varies from 0 to 13

percent. The present paper reports studies of this population, as well as attempts to determine the ecological factors influencing the maintenance of the dimorphism. Also, additional data concerning the inheritance of the pattern phases are presented.

### Materials and Methods

This study was conducted from 1970 to 1973 on Potts and Salt Pond mountains near the Mountain Lake Biological Station in Giles County, Virginia. The area, mostly in the Jefferson National Forest, was once a climax oak-chestnut forest. Destruction of the American chestnut by a fungal blight and removal of timber by logging have allowed additional oaks to become established. The forest is now primarily oak-hickory-maple. A shallow stream (Little Stony Creek) with an average width of 10 feet runs through the study area (Figure 1).

During 1970, salamanders were sampled at 17 sites along the old Salt Sulfur Turnpike (Route 613, Giles Co., Va.; Figure 1). Most sites were located at intervals of one-half mile along the road. In 1971, the area paralleling Little Stony Creek was studied, since this appeared to represent the local southern limit of occurrence of the unstriped form. In 1972, areas near Little Stony Creek and on the north side of Potts Mountain were the focal points of collection.

Individuals were captured under rocks and logs and in the leaf litter. Most of the available cover was examined to avoid collecting bias. Nearly all of the collecting sites had more logs than rocks. Although some salamanders were found under small branches, they seemed more abundant under cover larger than 3 inches in diameter. Similar observations were made in Michigan by Test and Bingham (1948).

The animals were scored for presence or absence of the mid-dorsal stripe. Any animal with contrasting dorsal pigment was scored as "striped." The cover was recorded for each animal. During the first year of the study, animal length (tip of snout to tip of tail) was recorded. Animals with regenerating tails were not measured. Vegetation within three feet of the capture site, amount of moisture under the cover, and soil temperature were recorded for some individuals. Moisture was measured with a moisture meter having a scale of 0 (dry) to 5 (very moist). At first, animals

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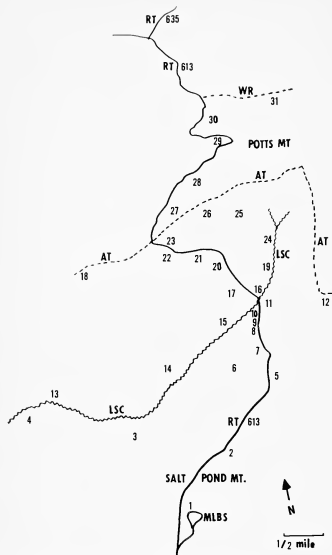


FIG. 1.—Map of Route 613 as it passes over Potts and Salt Pond Mountains in Giles County, Virginia. Numbers 1–31 refer to sampling sites. WR = White Rocks Recreation Center, AT = Appalachian Trail, LSC = Little Stony Creek, MLBS = Mountain Lake Biological Station of the University of Virginia.

were toe-clipped to keep track of recaptures and migration among sites, but clipping was later abandoned because the number of recaptures was extremely small, and no migration was observed. The animals sampled were not sexed. However, there is reason to believe that no difference exists in the proportions of striped and unstriped forms in the two sexes in this region, since Highton (1959) found that 83.3 percent of 314 females and 86.3 percent of 400 males in his Potts Mountain collections were striped ( $\chi^2_{(1)} = 0.678$ ;  $0.3 < P < 0.5$ ).

After each animal was scored, it was returned where found and the cover replaced. The only individuals removed from the population were brooding females and their clutches, and a few unusual specimens.

In 1973, daily high-low temperatures were recorded during July at Sites 1, 10, 23 and 29 using a maximum-minimum thermometer. The thermometers were placed on tree trunks approximately one foot from the ground at sites 10, 23 and 29. Readings

for site 1 were taken from the official weather station which is there.

A plant survey was also conducted in areas 5, 10, 19, 21, 23, 27 and 29. Trees greater than 3 inches in diameter were recorded in a strip 8 feet wide. Sampling was continued until 100 trees were scored.

### Results

In the sites studied, the phenotypic frequencies varied from 0 to 4 percent south of Little Stony Creek and from 4 to 13 percent north of Little Stony Creek (Table 1, Figure 1). Since data from previous collections at site 23 were available (see Table 2), all samples from this site were tested for homogeneity ( $\chi^2_{(7)} = 5.394$ ;  $.50 < P < .70$ ). There was no evidence of heterogeneity among the different collections.

The data from collections in 1970 were analyzed to assess association between individual pattern, length and the type of cover under which the animal was found. A two-way analysis of variance indicates that the size of an individual and type of cover are significantly associated ( $P < 0.01$ ). Larger individuals are found under rocks and smaller individuals are found under logs. No significant relationship was detected between size and color, and no interaction between color and cover.

No association is evident between the type of vegetation and the frequency of forms of *P. cinereus*. For example, *Acer rubrum* is the dominant tree in areas 5, 10, and 27 where the frequencies of unstriped are 0, 2 and 11 percent respectively. In areas 23 and 29 where the unstriped frequencies are highest, 13 and 12 percent respectively, the dominant trees are different. In area 23 *Quercus rubra* and *Q. alba* are dominant and in area 29 *Betula lenta* and *Acer rubrum*.

Moisture affects the activity of salamanders, since one finds more salamanders near the surface when surface moisture is high (Test 1955, Heatwole 1962, personal observation). Moisture readings were taken at the capture sites of 550 individuals. In the eight areas where moisture was recorded, the mean moisture level was higher for striped individuals at three sites and higher for unstriped at five sites. Using Fisher's exact test, no evidence was found that surface moisture is a controlling factor in the selection of habitat by striped and unstriped ( $P = 0.726$ ).

Altitude has little correlation with phenotype distribution (Figure 1, Table 1). A graphical test for association (Quenouille, 1959) showed no relation between altitude and pattern. However, regression analysis (Figure 2) between frequency of the pattern phases and distance in a north-south direction demonstrates that a significant relationship ( $b = 6.64$ ,  $P < .00001$ ) exists between the frequency of striped animals and north-south distance. Thus, a clear north-south cline exists.

Our experiences are similar to those of Highton (1972) in that *P. cinereus* is much more active during cooler weather. During a typical summer collecting trip, 25 to 35 animals were found within one hour while in September at site 23 more than 70 individuals were found within one hour. However, data from summer and fall collections were not heterogeneous.

In areas 1 and 10, where frequencies of unstriped



TABLE 1  
Numbers of animals sampled at each site, and frequencies of the Unstriped phase of *P. cinereus* on Potts and Salt Pond Mountains, 1970-1972.

Site	Elevation in Feet	Number of animals Years sampled				Frequency of unstriped Years sampled			
		'70	'71	'72	Total	'70	'71	'72	Total
1	3860	62	43		105	.000	.000		.000
2	3830	91			91	.000			.000
3	3500		42		42	.000			.000
4	3100		41		41		.000		.000
5	3720	50	36		86	.000	.000		.000
6	3600		56		56		.000		.000
7	3650		153		153		.013		.013
8	3625		74	66	140		.000	.000	.000
9	3575		123		123		.024		.024
10	3550	111	137	33	281	.009	.044	.000	.018
11	3770		47		47		.043		.043
12	3750			23	23			.000	.000
13	3150		45		45		.067		.067
14	3250		48		48		.042		.042
15	3550		52		52		.058		.058
16	3770		87		87		.046		.046
17	3700	105			105	.048			.048
18	3950	57		27	84	.105		.148	.127
19	3800		101	60	161		.089	.133	.111
20	3750	161	52		213	.071	.038		.055
21	3850	52			52	.077			.077
22	3900	76			76	.105			.105
23	3950	54	107	56	217	.148	.103	.143	.131
24	3850		54		54		.074		.074
25	4000		47		47		.085		.085
26	4120	55			55	.073			.073
27	3850	51	28		79	.059	.179		.119
28	3650	65			65	.077			.077
29	3350	51			51	.118			.118
30	3050	50			50	.100			.100
31	3000	50			50	.100			.100

salamanders are low, the average daily temperature was higher than in areas 23 and 29 where the frequencies are much higher (Table 3). In areas 1 and 10, the range between average high and low is 10.0°C and 10.8°C, respectively, while in areas 23 and 29 it is 7.2°C and 5.3°C.

Since *P. cinereus* has never been bred in the laboratory, little is known directly about the inheritance of color phase. It has been necessary to use data from clutches taken in the field for making genetic deductions. In 1958, Highton collected 19 clutches near the

summit of Potts Mt. (area 26, east and west of the firetower) (Highton 1959). During the present study one of us (MAA) collected an additional 16 clutches there. These data are summarized in Table 4.

Two clutches are noteworthy. Highton found an unstriped female which produced a clutch of 8 striped offspring (1958-29) and MAA found an unstriped female which produced a clutch of 8 unstriped offspring (1970-1). Table 5 shows the expected proportions of offspring from unstriped females if striping or unstriping is dominant.

TABLE 2  
Data from previous collections of *P. cinereus* at site 23 on Potts Mountain. The Jopson collections were made by the Zoology 204 (Herpetology) classes at Mountain Lake Biological Station.

Sample size	Number Unstriped	Freq. Unstriped	Dates	Collectors
168	13	.0774	August, 1966	Jopson
224	22	.0982	August, 1968	Jopson
161	19	.1180	June, 1970	Jopson
54	8	.1481	July 20, 1970	Angleberger & Chinnici
			July 21, 1970	
107	11	.1028	June 17, 1971	
			July 6, 1971	Angleberger
			July 7, 1971	
94	7	.0745	Sept. 25, 1971	Angleberger & Chinnici
198	17	.0859	June, 1972	Jopson
56	8	.1429	June 24, 1972	
			Aug. 15, 1972	Angleberger

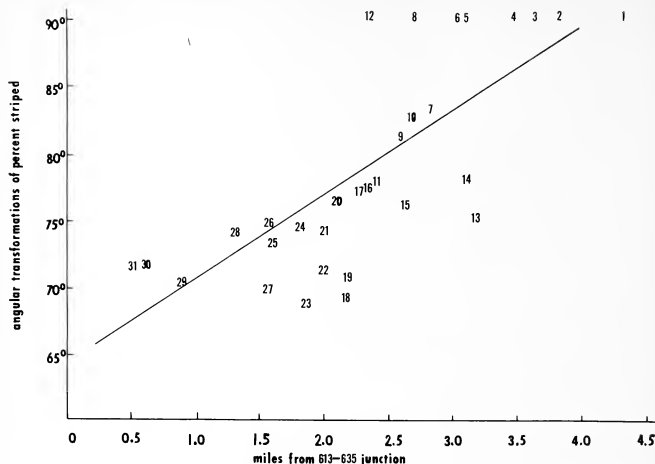


FIG. 2.—Graph of the plot of miles from the junction of Routes 613 and 635 in a strict North-South direction against the angular transformation of percent striped salamanders in samples 1-31.

### Discussion

This study was undertaken to determine which ecological factors are responsible for the distribution of the two color phases of *Plethodon cinereus* on Potts Mtn., Giles Co., Virginia. A north-south cline exists on Potts Mountain. At the Mountain Lake Biological Station the unstriped form comprises less than one percent of the population. Five miles north of the station, the population contains up to 13 percent unstriped animals. Located near the southern limit of the cline is Little Stony Creek. From samples reported in this paper and earlier collections made by Highton (unpublished), it is clear that the populations south of Little Stony Creek have extremely low frequencies of the unstriped color phase. It is

possible that this stream restricts southern migration of the unstriped phase.

Highton (1962) points out that areas of abundance of the unstriped form are scattered from Canada to the southern Coastal Plain of Maryland. The cline which exists on Potts Mt. is evidently local.

At site 23, where data are available for a number of years, there is no evidence of heterogeneity. This indicates that the frequencies in these populations have remained fairly stable over a number of years. Therefore it is likely that the frequencies at the remaining sites also are stable.

*P. cinereus* prefers cool, damp, wooded areas and makes use of whatever cover is available. More salamanders were collected beneath logs than beneath rocks. This may be due to the greater abundance of such cover on the forest floor. There is no relationship between the color of the individual and the type of cover utilized. However, there is a detectable association between the type of cover and the size of the individuals. It may be that the larger animals have better burrowing ability and, therefore, seek cover under larger and more firmly imbedded objects.

The type of habitat at the sites varied somewhat and the type of vegetation was not the same throughout. The plant surveys show some difference in the dominant trees in the collection areas but no relationship is evident between the type of vegetation and proportion of the color type in the population.

TABLE 3

Summarized daily temperature data (in degrees Centigrade) for July, 1973. One low temperature reading each at sites 10 and 23 was not recorded

	Site 1	Site 10	Site 23	Site 29
Highest	27.2	27.2	23.3	24.4
Lowest	7.8	8.3	8.9	11.7
Ave. High	23.7	22.8	21.2	21.1
Ave. Low	13.7	12.0	14.0	15.8
Range of	10.0	10.8	7.2	5.3
Averages				

TABLE 4

Data from 35 clutches found on Potts Mountain. S = Striped, U = Unstriped

Site #	Clutch #	Freq. of striped in population	Phenotype of female	Number of offspring	
				S	U
Data of Highton (1959)					
26	1958-12	.8515	striped	11	0
	1958-13		unstriped	5	5
	1958-14		striped	8	0
	1958-15		unstriped	3	3
	1958-16		striped	9	0
	1958-17		striped	3	0
	1958-18		striped	6	0
	1958-19		striped	6	0
	1958-20		striped	4	0
	1958-21		striped	3	0
	1958-22		striped	7	0
	1958-23		striped	6	1
	1958-24		striped	3	3
	1958-25		striped	5	0
	1958-26		striped	5	1
	1958-27		striped	9	1
	1958-28		striped	2	1
	1958-29		unstriped	8	0
	1958-30		striped	8	0
Data of Angleberger and Chinnici					
28	1970-1	.8824	unstriped	0	8
	1970-2		striped	9	0
23	1971-1	.9091	unstriped	4	6
	1971-2	.9574	striped	8	0
19	1971-3	.9333	striped	10	0
24	1971-4	.9259	striped	8	0
	1971-5		striped	7	0
8	1971-6		striped	9	0
	1972-1	.8667	striped	5	0
11	1972-2		striped	9	0
	1972-3	.9333	striped	8	0
19	1972-4		striped	6	0
	1972-5		striped	6	0
19	1972-6		striped	8	0
	1973-1	.9109	unstriped	4	1
	1973-2		striped	9	0

Test (1955) suggests that the amount and distribution of moisture might influence color phase frequencies. Our data do not support this hypothesis. The availability of these salamanders is increased by moisture, but there is no evidence for a differential effect on the two color phases, and it is unlikely that a difference in humidity is the sole ecological factor responsible for maintenance of the polymorphism or distribution of the phenotypes. Also, altitude appears to have little or no effect on the frequencies of the color phases in this area.

Samples from southeastern Michigan (Test 1955) tended to be smaller in the summer but there was no significant difference in the frequency of color phases from season to season. This also was found to be true in the Potts Mtn. collections. In testing the stability of the frequency of the color phases in a population in Ithaca, New York, Brown (1965) also did not find large seasonal fluctuations.

Temperature may be one of the factors influencing the proportions of color phases. Data from the pres-

ent study show that the average daily temperature was higher in areas where the frequency of unstriped salamanders was lower. This suggests that the unstriped form is favored in a cooler habitat. Data also show that the range between the average high and low was greater where frequencies of the striped form were high. This may indicate that more extreme daily temperature fluctuation favors the striped form. Looking at the geographical locations within the entire range where the unstriped form occurs in relatively high frequencies, however, we may nearly rule out temperature as a factor, since some localities are as far north as Canada and some as far south as the Coastal Plain of Maryland. The variation in temperature between these areas is much greater than in the Potts Mountain sampling sites.

As regards the genetics of striping, direct information cannot be obtained since *Plethodon cinereus* will not breed in the laboratory. Furthermore, it is not known how often females mate in nature, a factor which can affect attempts to interpret phenotypic ratios when only the brooding female parent is captured (Highton 1966). Saylor (1966) reported that in Maryland populations no females were found with large eggs after June, indicating that oviposition takes place during that month.

One can make use of striping frequencies from clutches and their captured brooding female parents to estimate the probability that one or the other phenotype is dominant (Highton 1959, 1975). Using this technique, Highton (1959) concluded from studying clutches from Potts Mtn. that inheritance of striping is unifactorial and dominant. Additional studies, from Giles Co. and Greene Co., Va. populations, have led Highton (1975) to revise his earlier hypothesis so that a two-locus epistatic system controls the striping dimorphism. According to this, *A-B*

TABLE 5

Data from clutches with unstriped female parents found in the field showing gene frequencies and expected proportions of color forms if (1) striping is dominant or (2) unstriping is dominant

	Highton	Angleberger
no. of clutches	3	3
mean percent striped in areas	85.15	90.08
gene freqs. if striped dominant	p = .6147 q = .3853	p = .6850 q = .3150
gene freqs. if unstriped dominant	p = .9228 q = .0772	p = .9491 q = .0509
expected percent of striped offspring from unstriped female if striped is dominant	61.47	68.50
expected percent of striped offspring from unstriped female if unstriped is dominant	44.29	46.10
observed percent of striped offspring from unstriped female	66.67	34.78

—, *A—bb*, and *aabb* produce the striped phenotype while *aabB*—produces no strip. Highton claims that stripe appears dominant in Giles Co. because the *B* allele is fixed or nearly fixed there and striping appears recessive in Greene Co., because the *a* allele is fixed or nearly fixed there.

Clutch data in the present study do not clearly indicate that the striping phenotype is dominant in the Potts Mtn. area. Using the method of Highton (1959), it is found that our clutches from unstriped females produce an overall frequency of striped offspring closer to the expected frequency if the unstriped phenotype is dominant (see Table 5). However, our data may also support the opposite hypothesis as well. If striping is dominant, the following types of clutches would be expected: A striped female could have only: (1) an all striped brood or (2) a mixed brood. It is highly unlikely that a striped female would produce an entire clutch of unstriped individuals. Depending upon the genotype of her mate, an unstriped female could have: (1) an all striped brood, (2) a mixed brood, or (3) an all unstriped brood. All types of clutches have been found except those consisting entirely of unstriped individuals from striped female parents.

The clutch of 8 striped young with an unstriped female (1958–29) was found by Highton in an area where 85 percent of the population was striped. If striping is dominant, then in this area 37.79 percent of the individuals would be expected to be homozygous for striped and 47.37 percent would be expected to be heterozygous. If unstriped is dominant, the probability of an unstriped female having such a brood would be .0003. If striped is dominant, a homozygous recessive unstriped female would be expected to have all striped offspring every time she mated with a homozygous dominant striped male (Highton 1959).

If 88 percent of the population were striped (average of the areas where unstriped clutches were found), of six clutches with unstriped females, the expected proportions of the types of clutches would be: 2 clutches with all striped offspring, 3 clutches with mixed, and 1 clutch with all unstriped. The actual proportions found (see Table 4) are: 1 clutch with all striped, 4 clutches with mixed offspring and 1 clutch with all unstriped. Thus, these data are consistent with the hypothesis that striping is dominant.

Of the various ecological factors which were examined in this study, there is no evidence to indicate that any single factor is completely responsible for the distribution of color phases. On the other hand, most cannot entirely be ruled out. It is probable that a

combination of factors is responsible for maintaining the polymorphism.

*Acknowledgments*—With gratitude, we wish to acknowledge those who gave their time to offer suggestions, read and edit the manuscript, and aid in collections: Dr. J. J. Murray, Jr., University of Virginia; Dr. Harry G. M. Jopson, Bridgewater College; Dr. Susan M. Moyle, Centre College of Kentucky; Dr. David W. Johnston, University of Florida; Dr. James Organ, City College of New York; Dr. Thomas C. Emmel, University of Florida; and Mr. Wayne Angleberger. Drs. Charles Blem and David Cundall, both of Virginia Commonwealth University, read and criticized an earlier version of this manuscript. Dr. Richard Highton, University of Maryland, provided us with some unpublished data from his extensive collections. A very special thanks to all of them.

Part of this work was done under grants from the National Science Foundation. We also are grateful to the co-directors of the Mountain Lake Biological Station, Drs. J. J. Murray, Jr. and James L. Riepel, both of the University of Virginia, for providing facilities for this research.

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## Abstract of Paper Section of Agricultural Sciences

Fifty-third Annual Meeting of the  
Virginia Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

TOXICITY OF DIQUAT AND ENDOTHALL SEPARATELY AND COMBINED ON SEVERAL SPECIES OF AQUATIC PLANTS. C. R. Berry, Jr.,\* and C. B. Schreck.\* Dept. of Fisheries and Wildlife Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The herbicides, diquat and potassium endothall, were tested separately and as a 1:1 mixture to compare the phytotoxicity of each formulation to four aquatic plants and one filamentous algae. An effective treatment range was determined. Concentrations tested ranged from 0.11 mg/l to 4.0 mg/l of each herbicide separately. Identical concentrations of each were combined to form the mixture. Phytotoxicity was monitored using dissolved oxygen analysis, microscopic examination, and visual toxicity ratings. A toxic index was determined using the average for replicates of each formulation on the five test species.

The toxicity index for diquat and the mixture for all species of plants was greater than for endothall at all concentrations. Plants killed by diquat and the mixture exhibited similar morphological changes. Duckweed was most susceptible with egeria, elodea, *Lyngbya*, and coontail following in decreasing order of susceptibility. Dissolved oxygen analysis indicated that photosynthesis of *Lyngbya* and elodea was immediately affected by diquat and the mixture. The results show that a 1:1 mixture of diquat and endothall is not advantageous when compared to similar treatment levels of diquat alone. (Supported by U.S. Army O.E.C. Contract No. DAW 65-74-C-0013; FIW Contribution No. 75-17).

## Abstracts of Papers Section of Education

Fifty-third Annual Meeting of the  
Virginia Academy of Science, May 6-9, 1975, Harrisonburg, Virginia

GLASSBLOWING INSTRUCTION IN THE HIGH SCHOOL.  
Frank Akers. Glenvar High School, Salem,  
Va. 24153

Glassblowing has been introduced on an extra-curricular basis at Glenvar High School. Participants are taught the fundamentals of scientific glassblowing using "Pyrex" glass, and ornamental glassworking using both hard and soft glass. Student progress is self-paced; they have access to the equipment during school hours and may increase their skills to any level desired.

Financial assistance from the Glenvar High School Science Club and the Department of Program Planning and Analysis of Roanoke County Schools is gratefully acknowledged.

EARTH SCIENCE AS A MODEL FOR IMPROVING SECONDARY SCIENCE IN VIRGINIA. Joseph D. Exline\*, and Franklin D. Kizer, State Department of Education, Richmond, Va. 23216.

A recent statewide survey of earth science education in Virginia indicates that additional emphasis is necessary to make secondary earth science a first-rate, laboratory-oriented, science program. Indications are that more emphasis needs to be placed upon the development of additional pre-service and inservice programs for secondary earth science teachers.

For the future, developing statewide objectives for secondary earth science education should include the talents and efforts of all these individuals--teachers, supervisors, college educators, etc.--who are directly responsible for this aspect of student learning. For these efforts to produce the greatest benefit, an effective communications network must be employed.

A communications model, with earth science as the vehicle, is proposed. This model can produce, through the regional concept, a statewide effort for improving secondary earth science education. This communications model can provide a means for the development of statewide objectives for earth science education and coordinate statewide efforts for better achieving these objectives. Because of the unifying potential of the model, each individual effort can produce a multiplier effect for secondary earth science education in Virginia. Eventually, all areas of secondary science could be administered through a similar plan.

ISIS-INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM.  
R.N. Giese. School of Education, The College of William and Mary, Williamsburg, Va. 23185

ISIS is an NSF funded instructional system being developed for the non-college bound student as well as the college bound who doesn't plan a college science major. ISIS's instructional unit is the self-paced, activity-centered minicourse which explores everyday phenomena and shows science as a useful, understandable way of knowing. It doesn't attempt to generate scientists per se. Minicourses will be non-sequential, take 3 weeks, and focus on topics of high interest and consequence to students. Each minicourse has core, advanced and excursion activities. Core activities develop the minimum objectives via high interest phenomena. The advanced activities emphasize the principles underlying the phenomena. Excursions extend the core materials. Students can skip activities whose content they show mastery of on a pretest. Minicourses also include post-tests.

ISIS is not a curriculum. The course scope and sequence must be determined locally. By emphasizing the advanced activities of selected minicourses, schools can articulate year-long Bio., Chem. and Phys. courses. Emphasizing the core of selected minicourses would articulate a General Sci., Biological or Physical Sci. course.

Stephen A. Henderson, Ertle Thompson, Sci. Ed., Univ. of Va. Charlottesville, VA 22903 and Elizabeth Carr, Model Laboratory School, Eastern Ky. Univ., Richmond, Ky. 40475.

The middle school philosophy and organization pattern provides for exploration in both academic and career areas. Accordingly, greater flexibility and more course alternatives usually exist and students are given more freedom in planning their own program. This study examines the criteria students utilized in selecting one of the two science courses available to students in grades 6-8 at Model Laboratory School. The two courses offered were ISCS Level I and Environmental Studies. Both courses were team taught by experienced teachers in well equipped laboratories. The class organization, content and method of instruction were the major variables in the two programs.

A questionnaire was used to collect data concerning the reasons for course selection, quality of advisement and general attitude toward the middle school program. Multiple regression analysis was utilized to determine the significance of identified variables on course selection.

Interest, teacher preference and class organization were listed as the major reasons for science course selection. A significant relationship was also observed between previous experience in the course (1st semester), the quality of advisement and course selection.

ENVIRONMENTAL EDUCATION IN ORANGE COUNTY, VIRGINIA. H. B. Lantz, Jr\*. Orange County High School, Orange, Va. 22960, and Norlyn Bodkin. Dept. of Biology, Madison Col., Harrisonburg, Va. 22801

Environmental education is not just something to be taught and learned, but rather is a way of teaching and learning. That belief forms the basis for operation of Project COMSEP. COMSEP (Comprehensive School Ecology Program) is an ESEA Title III project designed to give students and members of the community a better understanding of the interrelationships of man and other organisms to their environments and raising questions of individual and societal culpability in the use and misuse of natural resources. Learning experiences in environmental education are provided for approximately 4,000 students in grades K-12. There are four major components of COMSEP: environmental interpretation centers, extensive student involvement, inservice training for teachers, and much community involvement. Evaluation instruments administered to participating students and teachers revealed that both increased their knowledge and appreciation of our environments, while teachers showed positive change in attitude and teaching behavior. This program has been well received and supported within the community.

ENVIRONMENTAL EDUCATION: NUCLEAR POWER. Joseph J. Law and Robert H. Lehman, Dept. of Natural Sciences, Longwood College, Farmville, Va. 23901

Nuclear power represents 30% of the energy for generating electricity in Virginia; by 1980 it will account for 50%. There is no reasonable alternative to an increased use of nuclear power to satisfy our nation-wide energy needs. However, there has been considerable public controversy over this clean, safe, economic, and reliable energy source. The controversial issues arise largely from the environmental impacts. There is still an undercurrent of fear about certain misunderstood aspects of nuclear power reactors and their environmental effects.

While environmental pollution is now a popular topic in science courses, the environmental aspects of nuclear power generation have not been well integrated into teaching plans. Knowledge is the key to nuclear acceptability. Therefore, transmitting of unbiased information on the effects of nuclear power production on the environment to our students and society as a whole is urged. The students, who will be the decision makers tomorrow, can hardly obtain this kind of information unless science educators help bring it to them. Science educators must make a special effort to dispel the unfair and inaccurate information that the opponents of nuclear power are creating regarding nuclear power, which is vital for our survival.

SOME METHODS AND TECHNIQUES FOR THE STUDY OF SOIL ARTHROPODS IN HIGH SCHOOL BIOLOGY. Edgar P. McConnell. Science Dept., McLean High School, McLean, Va. 22101

The origins of the study of soil arthropods, and the significance of arthropod faunas in the formation and maintenance of particular soil types and horizons are briefly discussed.

The faunal assemblages to be found in litter, topsoil, and subsoil are outlined. Factors which may cause population "explosions" effects for individual groups are noted. Standard and modified collection methods are covered in detail. Suggestions to provide quantitative data on sample sizes and population surveys are provided, as well as a format for a collection record sheet suitable for both field work and permanent laboratory records.

A bibliography is supplied of references containing both general and specific information on the study of soil arthropodan faunas.

## News and Notes

### The Dismal Swamp Project

By recent action of Council, the Dismal Swamp Editorial Board will work with the Editor of the Journal in bringing out the projected series of papers on the Dismal Swamp in the Virginia Journal of Science. The members of the DSEB, Drs. Robert Ake (ODU), E. Fred Benfield (VPI&SU), Arthur Buikema (VPI&SU) and Paul Kirk (ODU), are now preparing the first of these papers for publication in 1976. The series will be an important one for anyone interested in any aspect of the "Great Dismal", one of Virginia's most striking natural features.

### Mountain Lake Biological Station 1976 Announcement

The University of Virginia announces eight graduate courses in biology to be offered at the Mountain Lake Biological Station this summer. They are as follows:

First Term: June 10—July 13

Taxonomy of Seed Plants, Dr. Carl S. Keener, Pennsylvania State University  
Aquatic Ecology, Dr. George M. Simmons, Jr., Virginia Polytechnic Institute & S.U.  
Herpetology, Dr. Harry G. M. Jopson, Bridgewater College  
Animal Behavior, Dr. Glenn Hausfater, University of Virginia

Second Term: July 15—August 17

Ecological Genetics, Dr. David A. West, Virginia Polytechnic Institute & S.U.  
Terrestrial Ecology, Dr. Raymond Dueser, University of Virginia  
Pteridology, Dr. Donald R. Farrar, Iowa State University  
Mammalogy, Dr. Charles O. Handley, Jr., United States National Museum

Four fellowships of \$150 each are to be awarded. Two North Carolina Botanical Garden fellowships will be awarded to superior students with preference to those who have previously held work scholarships at the Station. Two additional awards will be made from the Mountain Lake Fellowship Fund established by friends of Mountain Lake. Contributions are invited for additional support for this fund. The fellowships may not be held concurrently with any other stipend from the Station. The recipients of these awards are chosen by the Research and Awards Committee of the Department of Biology. Applications for awards should be sent to the Director, Mountain Lake Biological Station, Gilmer Hall, University of Virginia, Charlottesville, Virginia 22903.

### Solar-heater Science Building at The Madeira School

One of the largest functioning solar-heated buildings in the country was dedicated October 17, 1975. Built for the use of the science students at The Ma-

deria School, Greenway, Virginia, an independent, secondary school for girls, located near Washington, D.C., the structure is believed to be the first solar-heated academic building to be constructed entirely with private funds.

Solar energy provides heat and domestic hot water for the 9000 square foot building as well as an adjacent swimming pool. Planned before the rest of the world recognized the energy crisis, the structure is the result of The Madeira School's desire to provide the best possible facilities for its students, two-thirds of whom are enrolled in science courses each year, and of the school's desire to demonstrate that a building for the teaching of science could itself be a teacher of science. The Science Building opened for classes in September.

The most striking feature of the 1½ story, cedar-sided, trapezoidal structure is the 4000 square foot collector which slopes 26° from the horizontal and forms the roof of the central section of the building. The rectangular space beneath the collector is devoted to laboratory space and support facilities: preparation rooms, balance room, animal room and storage room. The exposed utility systems, an integral part of the interior architecture, are coded in bright colors. A triangular greenhouse at one end of the main level is balanced by a similarly shaped seminar room at the other. Photography laboratories and workrooms are located on the ground level.

Architects for The Madeira School's solar-heated science building are Arthur Cotton Moore Associates of Washington, D.C. Flack and Kurtz of New York were the engineers for the solar heating system. In an unusual move, no back up heating system was incorporated into the building. A boiler in the adjacent gymnasium will supply additional hot water if needed.

In his design, the architect made maximum use of the school's 400 acre campus which overlooks the Potomac River. A pathway connecting the upper and lower sections of the campus, passes under the solar roof. Windows allow a view through the laboratories to the woods on the north side of the building.

The collector, consisting of molded aluminum panels, over-laid with glass, creates a greenhouse effect. The sun's energy heats an oil which is pumped through the panels and thence to a 10,000 gallon water tank in the basement. There the oil flows through heat exchange coils, heating the water used to heat the building in a standard forced air system.

Nobel prize winner James D. Watson was the principal speaker at the dedication ceremony attended by alumnae, parents and friends of the seventy-year old school. In her welcoming remarks Headmistress Barbara Keyser said, "When I asked Madeira's Board of Directors to approve the building even though we did not have the funds in hand, I knew we were gambling with the financial future of the school. But the faith in our future as women entering seriously into the field of science, and the faith that we, in a small way, could demonstrate that private and independent groups can pioneer in showing solutions to national crises, justified the gamble."



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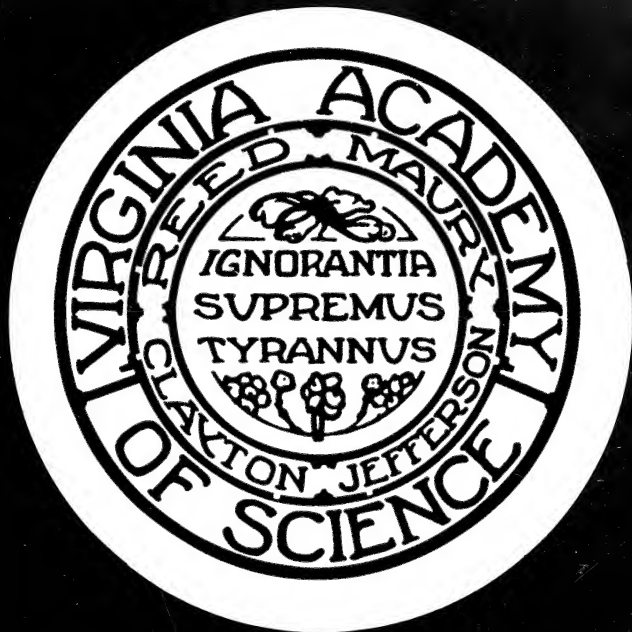




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# VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE



VOL. 27, NO. 1

SPRING 1976





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VIRGINIA ACADEMY OF SCIENCE

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# THE VIRGINIA JOURNAL OF SCIENCE

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Official Publication of the Virginia Academy of Science

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DAVID A. WEST

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Published quarterly by The Virginia Academy of Science, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Second-class postage paid at Richmond, Virginia.

Manuscripts for publication (other than section abstracts) should be sent to the Editor, Dr. David A. West, Department of Biology, V.P.I. and S.U., Blacksburg, Virginia 24061. Proof, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

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Harmon, H. H. 1960. Modern factor analysis. University of Chicago Press, Chicago.

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B. R. Woodson and M. Afzal

Department of Life Sciences  
Virginia State College  
Petersburg, VA 23803

Manuscript received December 19, 1973

Revised manuscript received March 1976

## The Taxonomy and Ecology of Algae in the Appomattox River, Chesterfield County, Virginia

**Abstract**—The study area in this investigation is the portion of the Appomattox River located in the southeastern section of the Matoaca district of Chesterfield County, Virginia. The objectives of this study were (1) the taxonomy of the algae inhabiting the stream and (2) a correlation of ecological factors and distribution of algae. The following observations are made:

- (1) The pH of the river ranged from 6.8 to 7.8. The water was found to be well buffered.
- (2) The water was well aerated. The dissolved oxygen concentration usually remained quite high (8–14.8 ppm).
- (3) The calcium values ranged from 3.4 to 6.4 ppm. The nitrogen (nitrate) and phosphorus (ortho) content ranged from 0.1 to 1.85 ppm and .016 to .074 ppm, respectively.
- (4) The algae collected during this study were species of Chlorophyta, Chrysophyta (Bacillariophyceae), and Cyanophyta (common to soft waters).
- (5) The Chlorophyta represented 50% of the total taxa reported, followed by the Chrysophyta representing 33%.
- (6) All of the genera collected are characteristic of the lotic environment but by no means restricted to it.
- (7) The genera with the highest numbers of species were *Naecklella* (7), and *Closterium* (6).
- (8) At the two most productive localities 148 and 121 species were recorded.

### Introduction

Algae are utilized as indicators of domestic sewage pollution and of natural purification in streams. The kinds and numbers of algae and other organisms in the polluted portion of a stream are different from those present in the unpolluted portion. The variation in the algal population at the different points or under different conditions of pollution constitutes one of the indices that can be applied to any desired location in the stream to determine the presence or absence of domestic sewage or other pollutants. It appears evident that particular genera or even species of algae, when considered alone, are not reliable indicators of organic pollution. When different kinds of algae are considered as a community, that group may be a reliable index.

Algae are also considered useful as indicators of the sources of a particular water supply. It is possible

to determine the probable source of surface water through a determination of the number and kinds of algae and related organisms present. Algae are useful to indicate the progress of sewage change in oxidation ponds, the pH and temperature changes of a stream or lake, the toxicity of industrial wastes and relatively high concentrations of chemicals such as sodium chloride, iron, and calcium phosphate.

In reviewing the literature of phycological studies in Virginia, it was found that no algal survey has been conducted in the Appomattox River in Chesterfield County, thereby establishing the reason for undertaking the present investigation. The objectives of this investigation were:

1. to collect and identify the algae found in the river and
2. to determine correlations between certain ecological factors and distribution of algae.

**Description of the Area and the River**—The study area is part of the Appomattox River, located in the southeastern part of the Matoaca district of Chesterfield County, Virginia. The river is a dividing line between the city of Petersburg and Chesterfield County. The study area begins near the western end of Randolph Farm and extends downstream approximately half a mile below a dam used by the Virginia Electric and Power generating system near the city of Petersburg.

Four sampling locations were selected. Station 1 is located upstream near the western end of a forest owned by Virginia State College. The river at this station passes through the forest and remains under shade of overhanging shore vegetation. The current is relatively swift at this station; however, numerous boulders provide protection areas for algal attachment. Approximately four miles upstream from station 1, a dam has been constructed which produced a 20–30 mile reservoir called Lake Chesdin. Station 2 is one mile farther downstream from station 1. The river bed at this station is also rocky. Station 3 is approximately one mile downstream from station 2. At this station the river bifurcates, and two branches rejoin after a short distance thereby creating a small island on the river bed. The island has a bearing on the flow, and the current is very slow. A small creek enters the river at this station, and the river bed is quite sandy. Station 4 is situated 2 miles further

downstream near a dam which is being used by the Virginia Electric and Power Company. The velocity of flow is very slow above the dam, and due to its presence the river spreads over a much larger area. Along the river, the soil is brown, loamy, river alluvium, and has medium to high natural fertility. Willows and sycamores line the river banks. *Justicia americana* (L) Vahl, *Podestema*, *Ceratophyllum* and a few species of *Carex* and *Juncus* are the main macrophytes of the river.

### Materials and Methods

Water samples for chemical analysis were collected along the northern margin of the river from four locations. Algal samples were mostly collected near the banks, as the water is quite deep towards mid-stream. Bottom collections were taken up to an accessible depth from such substances as fallen wood, stone, and submerged plants. Plankton samples were collected with a #20 Mesh Wisconsin Net. Fresh algal samples were examined in living condition upon return to the laboratory, and the algae were identified to the species level; however, lack of fruiting bodies in some forms prevented positive species identification.

Chemical analysis was done in the laboratory as outlined in "Standard Methods for the Examination of Water and Wastewater," 12th ed., 1965.

### Results

**Water analysis**—Table 1 summarizes the results of the water analyses at all stations.

**Taxonomic list**—The following abbreviations are used: Sp = spring, Su = summer, F = fall, W = winter. The numbers represent the stations on the river.

TABLE 1  
Results of Water Analysis

		Station 1	Station 2	Station 3	Station 4
Temp	Spring	16.3	16.67	18.67	19.0
	Summer	21.67	21.5	23.0	24.5
	Fall	14.0	16.5	13.5	10.5
pH	Spring	7.13	7.2	7.47	7.27
	Summer	7.2	7.2	7.2	7.35
	Fall	7.0	7.35	6.9	6.85
T.A.	Spring	22.3	22.3	25.3	22.0
	Summer	22.3	23.5	20.5	23.0
	Fall	21.0	23.5	16.0	15.5
D.O.	Spring	10.47	10.33	9.95	10.05
	Summer	8.67	8.9	8.6	8.3
	Fall	11.8	9.6	11.8	12.9
Ca	Spring	4.3	5.3	5.2	5.4
	Summer	5.5	5.6	5.5	5.85
	Fall	4.8	5.6	4.55	4.3
Mg	Spring	1.97	2.23	2.57	2.57
	Summer	2.95	2.6	2.25	2.95
	Fall	2.1	2.5	1.8	1.8
K	Spring	1.6	1.9	2.0	2.03
	Summer	2.27	2.05	2.0	2.4
	Fall	1.7	2.1	1.75	1.6
NO <sub>3</sub>	Spring	0.37	0.83	0.61	0.99
	Summer	1.27	1.2	1.75	1.13
	Fall	0.15	0.44	0.73	0.11
PO <sub>4</sub>	Spring	0.033	0.043	0.035	0.068
	Summer	0.032	0.026	0.026	0.022
	Fall	0.026	0.039	0.024	0.019

- DIVISION: Chlorophyta  
 CLASS: Chlorophyceae  
 ORDER: Volvocales  
 FAMILY: Chlamydomonadaceae  
*Chlamydomonas snowii* Printz 2, 3, 4—Sp, Su  
*Chlamydomonas globosa* Snow 3, 4—Su, F  
 FAMILY: Volvocaceae  
*Eudorina elegans* Ehr. 1, 2, 3, 4—Su, F  
*Pandorina morum* (Muell) Bory 1, 2, 3, 4—Su, F  
*Pleodorina californica* Shaw 1, 2, 4—Su  
*Volvox aureus* Ehr. 2, 3, 4—Su  
*Gonium sociale* Warm. 2, 4—Sp, Su  
 FAMILY: Palmellaceae  
*Sphaerocystis schroeteri* Chod. 1, 3, 4—F, Sp  
*Gleocystis gigas* (Kutz) Lager. 4—Su  
 ORDER: Tetrasporales  
 FAMILY: Tetrasporaceae  
*Tetraspora lamellosa* Presc. 1, 3, 4—Sp, F, W  
*T. lubrica* (Roth) Ag. 1, 3, 4—F, W  
 ORDER: Microsporales  
 FAMILY: Microsporaceae  
*Microspora floccosa* (Vauch) Thuret 1, 2, 4—Su, F, W  
*M. willana* Lager. 1, 2, 3, 4—F, W  
 ORDER: Chaetophorales  
 FAMILY: Chaetophoraceae  
*Stigeoclonium flagelliferum* Kuetz. 1, 2, 3, 4—Su, F, W  
*Aphanochaete repens* A. Braun 4—Su  
 ORDER: Cladophorales  
 FAMILY: Cladophoraceae  
*Cladophora fracta* (Dillw) Kuetz. 1, 2, 3, 4—Su, F, Sp  
*C. glomerata* (L) Kuetz. 1, 2, 3, 4  
*Pithophora oedogonia* (Mont) Wittt. 2, 3, 4—Su, F, Sp  
 ORDER: Oedogoniales  
 FAMILY: Oedogoniaceae  
*Bulbochaete* sp. 1, 2, 3, 4—Su  
*Oedogonium* sp. 1, 2, 3, 4—Su, F  
 ORDER: Chlorococcales  
 FAMILY: Chlorococcaceae  
*Chlorococcum humicola* (Naeg) Raben. 3, 4—Su  
*Golenkinia paucispina* W. W. 1, 2, 3, 4—Sp, Su  
 FAMILY: Characiaceae  
*Characium ambiguum* Herm. 2, 3, 4—S, F, W  
 FAMILY: Hydrodictyaceae  
*Pediastrum boryanum* (Turp) Menegh. 1, 2, 3, 4—Su  
*P. duplex* Meyen 1, 2, 3, 4—Sp, Su  
*P. duplex* var *clathratum* (A. Braun) Lager. 1, 2, 3, 4—Sp, Su  
*P. duplex* var *reticulatum* Lager. 2, 4—Sp, Su  
*P. tetras* (Ehr.) Ralfs 3, 4—Su, F  
*P. simplex* Lemmer. 1, 3, 4—Su  
 FAMILY: Coelastraceae  
*Coelastrum microsporum* Naegeli 1, 2, 3, 4—Su, F, Sp  
*C. cambricum* Archer 1, 2, 3, 4—Su  
 FAMILY: Botryococcaceae  
*Botryococcus sudeticus* Lemmer. 1, 2, 3—Su  
 FAMILY: Oocystaceae  
*Chlorella vulgaris* Beyer. 4—Sp, Su  
*Oocystis elliptica* W. West 3, 4—Su, F  
*O. pusilla* Hansg. 1, 2, 3, 4—Sp, Su, F  
*Eremosphaera viridis* DeBory 3, 4—Su  
*Treubaria setigerum* (Archer) G. M. Smith 1, 2, 3, 4—Su, F, Sp  
*Ankistrodesmus convolutus* Corda 1, 2, 3, 4—Su, F, Sp  
*A. falcatus* (Corda) Ralfs 1, 2, 3, 4—Su, F, Sp  
*Tetradron constrictum* G. M. Smith—Su, F

- FAMILY: Scenedesmaceae  
*Scenedesmus quadricauda* (Turp.) Breb. 2, 3, 4—Sp, Su  
*S. abundans* (Kirch.) Chod 1, 4—Su, F  
*S. quadricauda* var *Westii* G. M. Smith 2, 3, 4—Sp, Su  
*S. dimorphus* (Turp.) Kuetz. 2, 3, 4—Sp, Su  
*Actinastrum hantzschii* Lager. 2, 4, 1—Su, F, Sp  
*Crucigenta crucifera* (Wolle) Collins 1, 3, 4—Sp, Su  
ORDER: Zygnematales  
FAMILY: Zygnemataceae  
*Mougeotia* sp. 1, 2, 3, 4—Sp, Su  
*Spirogyra* sp. 1, 2, 3, 4—Su, F, Sp  
*Zygnema* sp. 1, 2, 3, 4—Sp, Su  
FAMILY: Mesotaniaceae  
*Netrium digitus* var *constritum* G. S. West-S. 2, 3, 4  
FAMILY: Desmidiaceae  
*Closterium lunula* Ehr. 1, 3, 4, F  
*C. leibleinii* Kuetz. 2, 3, 4—Su, F  
*C. diana* Ehr. 1, 2, 4—Su, F  
*C. incurvum* Breb. 3, 4—Su, F, Sp  
*C. subulatum* Kutz. 1, 3, 4—Su, F  
*Peurotaenium nodulosum* (Breb.) DeBory 2, 4—Su  
*Eleutherium ansatum* Ralfs. 2, 3, 4—Su, F  
*E. affine* Ralfs. 1, 3, 4—Su  
*Micrasterias radiata* Hess 2, 3, 4—Su  
*M. radiosa* Ralfs 2, 3, 4—Su, F  
*M. denticulata* var *angulosa* (Hantzsch) W. & G. S. West 3, 4—Su  
*Cosmarium punctatum* Borg. 1, 3, 4—Su  
*C. pyramidatum* Breb. 1, 2, 3—Su, F  
*C. pachydermum* Lund. 2, 3, 4—Su, F  
*C. obtusatum* Schmidle 2, 3, 4—Su  
*C. contractum* Kirch 3, 4  
*Xanthidium cristatum* var *uncinatum* Breb. 3, 4—Su  
*Arthodesmus convergens* Ehr. 3, 4—Su  
*Staurastrum americanum* 2, 3, 4—Su, F  
*S. leptocladum* var *insigne* W. & G. S. West 3, 4—Sp, Su, F  
*Hyalotheca dissiliens* (Smith) Breb. 1, 3, 4—Su, F, W  
*Desmidiium swartzii* Agardh. 1, 2, 3, 4—Su, F  
*D. baileyi* (Ralfs) Nordst. 2, 3—Su, F  
CLASS: Charophyceae  
ORDER: Charales  
TRIBE: Nitelleae  
*Nitella opaca* Ag. 4—Su  
DIVISION: Euglenophyta  
CLASS: Euglenophyceae  
ORDER: Euglenophyceae  
ORDER: Euglenales  
FAMILY: Euglenaceae  
*Euglena acus* Ehr. 1, 3, 4—Su  
*E. proxima* Dang. 2, 4—Su, F  
*Phacus orbicularis* Hubner 1, 2, 4—Su, F  
*P. longicauda* (Ehr.) Duj. 2, 3, 4—Su, F, Sp  
*Trachelomonas hispida* (Perty) Stein 2, 3, 4—Su, F, Sp  
DIVISION: Pyrrophyta  
CLASS: Dinophyceae  
ORDER: Peridinales  
FAMILY: Ceratiaceae  
*Ceratium hirundinella* 2, 3, 4—Su, F, W  
DIVISION: Chrysophyta  
CLASS: Xanthophyceae  
FAMILY: Tribonemataceae  
*Tribonema bombycinum* (Ag.) Derber & Solier 1, 2, 3, 4—Su, F, W  
CLASS: Chrysophyceae  
ORDER: Chrysomonadales  
FAMILY: Mallomonadaceae  
*Mallomonas apochromatica* Conard 2, 3—Su, F
- FAMILY: Synuraceae  
*Synura uvela* Ehr. 2, 3, 4—W, F, Su  
FAMILY: Ochromonadaceae  
*Dinobryon divergens* Imhof 1-3, 4—W, Sp, Su  
ORDER: Rhizochrysidales  
FAMILY: Rhizochrysidaceae  
*Lagynion reductum* Press. 2-4-Su  
CLASS: Bacillariophyceae  
ORDER: Centrales  
FAMILY: Coscinodiscaceae  
*Stephanodiscus hantzschii* Cleve. 2, 3, 4, Su, W  
*Coscinodiscus lacustris* 1, 3, 4—S, F, W  
*Melosira granulata* (Ehr) Ralfs 1, 2, 3, 4—Sp, Su, F, W  
*M. varians* C. A. Agardh. 2, 3, 4—S, Sp, F  
ORDER: Fragilariiales  
FAMILY: Tabellariaceae  
*Tabellaria fenestrata* (Lying) Kuetz. 2, 3, 4—Sp, Su, F, W  
FAMILY: Diatomaceae  
*Diatoma vulgare* Bory 1, 2, 3, 4—Su, W  
FAMILY: Fragilariaceae  
*Fragilaria virescens* Ralf. 1, 2, 3—Su, F  
*F. crotonensis* Kitton 1, 2, 3, 4—Sp, F, Su, W  
*F. capucina* Desmer. 1, 2, 4—Sp, F, Su, W  
*Asterionella formosa* Hassal 1, 2, 3, 4—Sp  
*Synedra rumpens* Grunow 1, 2, 3, 4—Sp, Su, F, W  
*S. ulna* (Nitz) Ehr. 1, 2, 3, 4—Su  
ORDER: Eunotiales  
FAMILY: Eunotiaceae  
*Eunotia pectinalis* (Kutz) Raben. 1, 2, 3, 4—Su, F, W  
*E. triodon* Ehr. 1, 3, 4—F, W  
ORDER: Achnanthes  
FAMILY: Achnanthes  
*Cocconeis placenticula* Ehr. 1, 2, 3, 4—F, W  
*Achnanthes lanceolata* (Breb.) Grunow 1, 2, 4—Su, F, W  
ORDER: Naviculales  
FAMILY: Naviculaceae  
*Amphipleura pellucida* Kuetz. 1, 2, 3—Su, F  
*Frustulia rhomboides* (Ehr.) deToni 1, 2, 3, 4—F, W  
*Gyrosigma acuminatum* (Sulliv) Boyer 1, 2, 4—Su, F, W  
*Pluerosigma strigosum* W. Smith 1, 2, 4—Su, F, W  
*Stauroneis phoenicenteron* Hust. 1, 2, 3, 4—Su, F, W  
*Navicula cuspidata* Kuetz. 1, 2, 3, 4—Su, F, W  
*N. radiosa* Kuetz. 1, 2, 3, 4—Su, W  
*N. cryptocephala* Kuetz. 1, 2, 3, 4—Su, F, W  
*N. rhynchocephala* Kuetz. 1, 2, 3, 4—Su, F, W  
*N. exigua* (Greg) O. Miller 1, 2, 3, 4—Su, W  
*N. anglica* Ralfs 1, 2, 3, 4—Su, F, W  
*Pinnularia biceps* Gregory 1—3, 4—F, W  
*P. major* Kuetz. 1, 2, 3, 4—Su, F, W  
FAMILY: Gomphonemataceae  
*Gomphonema parvulum* Kutz. 1, 2, 3, 4—F, W  
*G. angustatum* (Kuetz) Rabh. 2, 3—Su, F, W  
*G. constrictum* Ehr. Grunow 1, 2, 4—Su, F, W  
FAMILY: Cymbellaceae  
*Cymbella tumida* (Breb.) Van Heruck 1, 2, 3, 4—Su, F, W  
*C. turgida* (Gregory) Cleve. 1, 2, 4—F, W  
*C. parva* (Hemp) Kirchu. 1, 2—4—Su, W  
ORDER: Nitzschiales  
FAMILY: Nitzschaceae  
*Nitzschia fonticola* Grunow 1, 2, 3—Su, F, W  
*N. linearis* W. Smith 1, 2, 3, 4—F, W  
*N. sigma* (Kuetz) Sm. 1, 2, 3, 4—F, W  
*N. acicularis* W. Smith 1, 2, 3, 4—F, W

- N. vermicularis* (Kuetz) Grunow 1—3, 4—Su, F, W  
*N. dissipata* (Kuetz.) Grunow 1, 2, 3, 4—F, W  
 ORDER: Surirellales  
 FAMILY: Surirellaceae  
*Surirella elegans* Ehr. 1, 2, 3—Su, F, W  
*S. robusta* Cleve-Euler 3, 4—Su, F, W  
*S. ovalis* Breb. 1, 2, 3, 4—Su, F, W  
 DIVISION: Cyanophyta  
 CLASS: Cyanophyceae  
 ORDER: Chroococcales  
 FAMILY: Chroococcaceae  
*Chroococcus limneticus* Lemm. 2, 3, 4—Su  
*Microcystis aeruginosa* Kuetz. 1, 2, 3, 4—Su  
*Merismopedia glauca* (Ehr.) Naeg. 1, 2, 3, 4—Su, F, Sp  
*M. tenuissima* Lemm. 1, 2, 3, 4—Su, F, Sp  
*M. elegans* A. Braun. 1, 2, 3, 4—Sp, Su  
*Aphanothece gelatinosa* (Henn) Lemm. 3, 4—Su  
 CLASS: Oscillatoriales  
 FAMILY: Oscillatoriaceae  
*Spirulina major* Kuetz. 1, 2—4—Su  
*Oscillatoria limosa* (Roth) C. A. Agardh. 3, 4—Su, F  
*O. princeps* Vaucher 1, 2, 3, 4—Su  
*O. tenuis* C. A. Agardh 2, 3, 4—Sp, Su, F  
*O. amoena* (Kuetz) Gomont 1, 2, 3, 4—Su  
*O. acutissima* Kuff. 2, 3, 4—Su, F  
*Phormidium ambiguum* Gomont 3, 4—Su  
*Lyngbya birgei* G. M. Smith 2, 3, 4—Su, F, W  
 FAMILY: Nostocaceae  
*Anabaena affinis* Lemm. 2, 3, 4—Su  
*A. limnetica* G. M. Smith 1, 2, 3, 4—Su, F  
*A. spiroides* var. *crassa* Lemm. 2, 3, 4—Su, F  
 DIVISION: Rhodophyta  
 CLASS: Rhodophyceae  
 SUP-  
 CLASS: Florideae  
 ORDER: Nemalionales  
 FAMILY: Chantransiaceae  
*Audouinella violacea* (Kuetz.) Hammed 4—Su, F  
 FAMILY: Batrachospermaceae  
*Batrachospermum moniliforme* Roth 1—F, W

### Discussion

**Temperature**—Temperature readings for the study stream ranged from 5 to 29°C. It was not possible to record the temperature for each sampling date at the same hours. Some readings were taken during the morning hours and others in the afternoon; therefore, the effect of temperature as a limiting factor could not be measured accurately. Seasonal variations in temperature, however, were noted. A slight temperature variation was observed between the sampling stations, when readings were taken on the same dates as shown in Table 2.

A seasonal variation in algal species composition followed temperature changes. (See taxonomic list).

**pH**—The pH recorded during this study ranged from 6.8 to 7.8 and was in the optimum range for biological productivity. During this investigation, 23 species of desmids were recorded, showing a fairly good representation in the algal population of the river. Most desmids are selective of a pH range between 5 and 7, but Pearsall (1923) pointed out that the determining factor for desmid flora is the ratio Ca, Mg/Na, K. No attempt was made to determine this ratio; however, it appears that after water entered the

watershed, pH values did not limit the growth and distribution of desmids.

**Dissolved Oxygen**—Dissolved oxygen values ranged from 7.3 to 14.8 mg/l. The lowest value was recorded in the week following the flood of July, 1972 when water was still high (Table 2). The highest recorded temperature during this study was also on the same date (July 18, 1972). During this investigation, the river had two floods, as shown in Table 2, and a decrease in dissolved oxygen values was observed during both. The lowered oxygen concentrations are brought about by the wash-in of organic matter, scouring of algal vegetation from the river bed, and the decrease of photosynthesis caused by turbidity. Hynes (1970) has documented that dissolved oxygen decreases in certain rivers during floods, but it varies; also in small streams it increases due to turbulence.

A comparison of all stations on the same dates is shown in Table 2; a slight variation in oxygen content was observed. Relatively higher values were recorded at stations 3 and 4, which may be attributed to comparatively high photosynthetic activity, as these stations held relatively rich algal populations as compared to other stations.

During winter when oxygen concentrations were high, genera like *Diatoma*, *Gomphonema*, *Eunotia*, *Achnanthes*, *Draparnaldia*, and *Tribonema* were common. These genera as well as others have been documented as algae with high respiratory rates (Whitford and Schumacher 1963).

**Total Alkalinity**—Total alkalinity values ranged from 15 mg/l to 29 mg/l (Table 1). Low values were recorded during or just after the flood. The algal populations of the river were then greatly reduced, and only a few species were observed, a result attributed to the diluting and scouring effect of the flood. However, the water was well-buffered, and pH readings remained close to neutrality.

**Calcium and Magnesium**—Waters containing less than 50 mg/l of calcium are considered soft, and values less than 10 mg/l are considered poor for biological productivity (Reid 1961). The water of the Appomattox River is very soft according to this generalization. Calcium readings for the river ranged from 3.4 ppm to 6.4 ppm. Magnesium readings ranged from 1.6 ppm to 3.3 ppm. A genus like *Chara*, which flourishes in calcareous streams, was not observed in any collection. The algae of soft waters are largely desmids and certain species of Chrysophyceae, Myxophyceae, and Chlorophyceae.

The more calcium and magnesium in the water, other things being the same, the greater the productivity (Welch 1952). The water in this study would be considered unproductive. It is quite possible that the absence of certain species was due in part to low calcium and magnesium concentrations in the river.

**Nitrogen and Phosphorus**—Nitrogen has been placed high on the list of critical elements in algal ecology. The amount and form of available nitrogen may determine the algal community composition.

Nitrogen values ranged from 0.05 mg/l to 1.85 mg/l. An increase in nitrogen readings occurred after periods of rainfall and flooding of the stream. High nitrogen values recorded during summer months coincided with a rich algal flora. Woodson and Holo-

TABLE 2  
Results of Water Analysis for all Stations on Same Dates

Station	Time	Date	Temp °C	pH	D.O.*	T. Alkalinity	Ca*	Mg*	K*	N*	P*
1	12:00 noon	6-15-72	21.0	7.4	8.6	25	5.9	3.3	2.3	1.32	.019
2	12:30 p.m.	6-15-72	21.5	7.4	8.6	25	5.9	3.3	2.3	1.32	.019
3	12:50 p.m.	6-15-72	22.0	7.5	8.65	25	5.9	3.3	2.3	1.32	.019
4	1:15 p.m.	6-15-72	22.0	7.5	8.7	25	5.9	3.3	2.3	1.32	.019
1	3:10 p.m.	7-18-72	28.0	7.6	7.2	23	5.8	2.7	2.3	1.60	.022
2	3:40 p.m.	7-18-72	29.0	7.7	7.3	23	5.8	2.7	2.3	1.6	.022
3	4:00 p.m.	7-18-72	29.0	7.7	7.3	23	5.8	2.7	2.3	1.6	.022
4	4:30 p.m.	7-18-72	29.0	7.7	7.3	23	5.8	2.7	2.3	1.6	.002

\* Reported in parts per million (ppm)

TABLE 3  
Percentage Distribution of Species by Division

Division	Number	Percentage
Chlorophyta	76	50
Euglenophyta	5	3.3
Pyrrophyta	1	0.6
Chrysophyta	50	33
Cyanophyta	18	11.8
Rhodophyta	2	1.3
Totals	152	100

Total Numbers of Species Recorded at Each Station

Station #1	Station #2	Station #3	Station #4
96	105	121	148

man (1964) also reported high nitrogen readings for the Appomattox River during the summer. High nitrogen concentrations supporting rich algal flora suggest that the temperature changes which permitted increased algal population also permitted increased bacterial activity which possibly replenished nitrogen concentrations. The basin of Lake Chesdin drains farm land and possibly contributes to the increase in nitrogen concentration in the stream below the dam. Some lakes actually may increase the nitrate content of the downstream waters by nitrogen fixation in the reservoir (Hynes 1970).

Phosphorus is considered the most critical single factor in algal ecology. Phosphorus values ranged from 0.01 to 0.07 mg/l. Phosphates are normally low in natural bodies of water and because of a high demand for phosphorus in metabolism, it is utilized by growing organisms almost as fast as it becomes available. Laboratory experiments confirm that certain algae store phosphorus to an appreciable extent if it is available in excess (Welch 1952).

**Potassium**—Potassium is a requirement for all animals and plants. It is readily taken up by plants, both aquatic and terrestrial. Potassium values ranged from 1.4 to 2.7 ppm.

During this investigation, *Nitella* was observed only once along the southern bank of the river at station 4.

**Effect of Impoundments**—The impoundments of the drainage basin influence the stream ecology to a great extent. Dams produce a slack water area by reducing the current; the depth is increased and opportunities for plankton development are generally improved. The slow movements of water provide sufficient time for the development of large algal populations (Welch 1952).

The dam at station 4 provided conditions conducive to the development of algal communities, and the number of species was greater there than at other stations.

### Summary

During this investigation 152 species of algae were identified from four stations on the Appomattox River. The distribution of species by division is given in Table 3, together with the numbers of species recorded from each station. The summer flora, which was very rich, was dominated by members of the Chlorophyta. In the winter, when the flora was poor, the Chrysophyta were relatively abundant.

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Manuscript received May 25, 1975

Revised manuscript received January 19, 1976

## Racial Differences in Attitudes toward Population Control and Overpopulation as an Abstract Problem

**Abstract**—Groups of 57 and 65 black college students were compared with groups consisting of 74 white non-students and 80 white college students on attitudes toward population control, the relationship between population control and racial attitudes, and the perception of overpopulation as an abstract problem. Results showed: (a) Blacks were generally less likely to favor population control, (b) Blacks were more likely to believe that population control is synonymous with racial genocide ( $p < .001$ ), (c) among Whites favorable attitude toward Blacks was associated with favorable attitude toward population control, (d) 90% or more of both black and white Ss perceived the population problem abstractly, and (e) Blacks perceived the problem more abstractly than Whites. Explanations were offered for conflicting results of previous studies.

There is a controversy among population researchers as to whether Blacks are less inclined to support population control than Whites. Barnett (1972) found race to be useless as a predictor of differences in attitudes toward population control. McCutcheon (1974) found that Blacks averaged about one standard deviation below the mean of a scale on which high scores reflect favorable attitudes toward population control. Unfortunately, the small sample of Blacks ( $n = 6$ ) rendered any conclusions premature. In some cases it has appeared as though Blacks generally want slightly fewer children than Whites, although they tend to have more (Jaffe and Guttmacher 1968; Westoff and Westoff 1968). Since there seems to be a much higher incidence of unwanted childbirths in the black community, it should follow that Blacks would be desirous of birth control clinics in order to reduce or eliminate this problem. However, many Blacks are quite suspicious of family planning programs initiated by Whites (Willie 1971). Blacks are also less likely than Whites to view both the United States and the world population growth rates as serious (Barnett 1973; Buckhout 1972). The present research attempts to resolve this issue by comparing two samples of Whites and two samples of Blacks on attitudes toward population control. The imbalance of evidence suggests that Whites will favor

population control to a significantly greater degree than Blacks.

The primary reason given for black opposition to population control is the fear of racial genocide (Buckhout 1972; Fawcett 1970; Willie 1971); Blacks are concerned about the possibility of a general plan to reduce or eliminate the black population (Norton 1973; Turner and Darity 1971). Genocidal fears have been aroused where white middle class social workers or people operating birth control clinics in poor neighborhoods have pressured women to accept birth control services (Ehrlich, Ehrlich, and Holdren 1973). Belief that population control is a form of racial genocide has been found in all segments of the black community (Buckhout 1972; Darity, Turner, and Thiebaux 1971; Turner and Darity 1971; Willie 1971). On the other hand, some see the government's population program as basically designed to afford for the poor the same access to contraceptives and birth control information that the richer segments of the population already have (Ehrlich, Ehrlich, and Holdren 1973; Norton 1973). It could also be argued that those who do favor population control would be likely to be favorably disposed toward Blacks, since both positions call for social change. There are few data (but see Kammeyer, Yetman, and McClendon 1974) either to justify or to alleviate the fears of those who see population control as synonymous with racial genocide. The present study is, in part, an attempt to determine the validity of those fears and the extent to which they are prevalent, by examining the relationship between attitudes toward Blacks and attitudes toward population control among Whites and by asking both black and white Ss if "Population control is a plan to reduce the size of the black population." It was predicted that Blacks would be more likely than Whites to agree that population control is a devious plan. It was also predicted that favorable attitudes toward population control among Whites would be weakly associated with favorable attitudes toward Blacks. For Blacks, it was predicted that favorable attitudes toward population control would be weakly associated with favorable attitudes toward Whites.

There has been some controversy as to whether the

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population problem is abstractly perceived. The controversy centers around the notion that there is on the one hand, the relatively abstract attitude that a population problem generally exists. On the other hand, there appears to be a lack of realization that population growth is a direct threat to each family and will remain so until people accept personal responsibility for it (Barnett 1969; Brackbill 1971). Barnett (1970) and Corman and Schaefer (1973) found that peoples' attitudes toward overpopulation were not necessarily related to their feelings of personal responsibility toward the matter. Fischer (1971) found only moderate correlations ( $-.37$ ,  $-.25$ ,  $-.15$ ) among subgroups on preferred family size and concern about overpopulation. Crawford (1973) found that only five percent of his Ss felt that one of the advantages of birth control is the alleviation of overpopulation. Buckhout (1972) found that "In comparing the responses of subjects... on... abstract population control proposals to their personal inclinations in practicing birth control, there is a gap which suggests that it is all right for 'them' to be controlled (p. 23)." On the other hand, Fischer (1972) found a correlation of .70 between attitudes favoring population limitation and intention to have a small family and McCutcheon (1974) found a significant relationship between attitudes toward population control and number of children expected. In spite of this, the weight of evidence favors the prediction that Ss will express significantly greater support for statements that indicate that population is a problem than for statements calling for immediate action.

There is indirect evidence that abstract attitudes toward population control are related to black opposition to population control. The Gallup Organization in 1965 and 1967 found that even though people generally saw the population growth rate in the United States as serious, there was a strong tendency to see each of three other problems (crime, racial discrimination, and poverty) as even more serious (American Attitudes on Population Policy, 1968). Since these problems affect Blacks more so than Whites, it is conceivable that Blacks may see overpopulation as relatively abstract in relation to racial discrimination (real or perceived), poverty, crime, unemployment, housing, and other problems more crucial to immediate survival. In addition, Blacks could see themselves as relatively powerless to effect change because of a perceived inability to influence a national policy on population growth. They may also see population control largely as a problem of the white majority. Thus, in the present study it was predicted that Blacks would be even less inclined to view the population problem as a matter of personal responsibility than Whites.

### Method

**Subjects**—Participants in the present study were samples of black, general psychology students at a predominantly black two-year college in Washington, D.C., and white general psychology and sociology students at a two-year college in suburban northern Virginia. The former sample included 38 females while the latter included 44 females. Supplementary data were collected from black psychology students

at a predominantly black four-year college in southern Virginia, and a non-student sample of whites from six middle and upper-middle class neighborhoods in Fairfax County, Virginia and Prince Georges County, Maryland. Table 1 contains the sample sizes and means for age, father's education, and scores on the Population Opinion Poll for each sample.

**Attitudinal Measures**—All Ss filled out the Population Opinion Poll (POP), a seven-choice 30-item Likert-type attitude scale, the development, reliability, and validity of which has been described elsewhere (McCutcheon 1974)<sup>2</sup>. A thirty-first item, "Population control is a plan to reduce the size of the black population," was presented to all but the four-year college Blacks. Data were collected from the latter sample before the decision was made to include item 31. Responses to this item were scored separately. The front page of the POP asked for personal information about each S but several Ss in each group left one or more informational items blank.

An abstraction index was devised in order to compare each S's abstract beliefs about population control with her or his personal intention to do something about it. The latter was defined broadly to include support for abortion and laws that would tend to restrict population growth, as well as support for the direct limitation of family size. Responses to four POP items calling for strong and immediate action were compared with four abstract items also taken from the POP (see Table 2). The abstract items allowed for recognition that there is a population problem without suggesting the immediacy of it or the willingness of the respondent to act. Each S's abstraction index was determined by subtracting the score on the abstract items from the score on the action items. A remainder of zero indicated perfect consistency between perception of the population problem and willingness to take action.

Black Ss from the predominantly black two-year school also filled out a 14-item, seven-choice, Likert-type scale called Attitudes Toward Whites. This scale consisted of items culled from two attitude scales described by Shaw and Wright (1967) as "reasonably valid" (p. 395) and "satisfactory" (p. 411), and the Desegregation (D) Scale (Holtzman & Young, 1966). Items 4, 14, and 36 from Form A and items 6 and 36 from Form B of the Scale to Measure Attitudes Toward Defined Groups were used in Attitudes Toward

<sup>2</sup> The scale is on file as Document NAPS-02379. Order from Microfilm Publications, 305 East 46th Street, New York, N.Y. 10017. Remit \$1.50 for microfiche or \$5.00 for photocopy.

TABLE 1  
A comparison of subjects on sample size, age, father's education, and POP scores

Group	n	Age	Father's Education	POP Scores
Black				
Two-year	57	25.36	9.76	121.47
Four-year	65	19.38	—	134.14
White				
Two-year	80	25.39	13.34	148.25
Non-students	74	34.59	12.97	140.50

TABLE 2  
Items used in the abstraction index

Item No. and Content	Abstract vs. Action
3 Abortion should be used to help prevent overpopulation	Action
5 Our government should pass a law restricting the number of children per family	Action
6 The present population of the United States is not creating a strain on the ecology <sup>a</sup>	Abstract
10 As compared with other national problems, the population problem is relatively unimportant <sup>a</sup>	Abstract
13 Most of the large cities in the United States are already overpopulated	Abstract
15 Adults should have as many children as they are able to provide for <sup>a</sup>	Action
24 World population is currently increasing too quickly	Abstract
29 The government should stop giving tax benefits for having children	Action

<sup>a</sup> Reverse item before scoring

Whites. Items 2, 4, 5, 6, 8, 10, and 14 from the Anti-white scale, and items 46 and 51 from the D Scale were also used. It was necessary to modify slightly some items for the sake of clarity and to update others. For example, the term "black" was used in place of "colored" or "negro". All items were reversed by interchanging the terms "black" and "white" to form the Attitudes Toward Blacks scale. The scales were identical otherwise. High scores on both scales indicated that respondents were highly prejudiced.

**Procedure**—The Attitudes Toward Whites scale and the POP were administered to black Ss at the predominantly black two-year school. The tester, a black woman, told Ss that she was working on two research projects at the same time and that she would appreciate it if they would fill out both questionnaires. Five people refused to participate and data were collected from four whites. White Ss were given Attitudes Toward Blacks but their data were later discarded because of the small *n*. Attitudes Toward Blacks and the POP were given to white Ss at the predominantly white two-year school. The testers were three white males who individually presented the same information and the same request as the black tester to five classes. In neither case was there any clue given that would lead Ss to believe that responses to the two instruments were related. There were four black Ss in the latter sample; these individuals filled out Attitudes Toward Whites but their data were also discarded.

Black Ss at a predominantly black, four-year college were given the POP to fill out in class by their black male instructor. Data from these Ss were collected before the decision to use Attitudes Toward Blacks. A primarily non-student sample of whites from Washington, D.C.'s suburbs were asked to fill out the POP and Attitudes Toward Blacks. Contacts were made by four male and two female student interviewers who went to every third home and administered both instruments in the same way that they were administered to the student samples. Sev-

eral residents were not home and 26 refused to participate. Interviewers were briefed about the study after they had collected their data. The Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe 1960) and Attitudes Toward Blacks were administered to an additional sample of general psychology students from the predominantly white two-year school. This was done in order to obtain an estimate of the extent to which white Ss were understating their negative views toward Blacks because it might be socially desirable to appear unprejudiced.

### Results and Discussion

An *F* test showed that groups were significantly different on age ( $F = 40.98$ ,  $df = 3/271$ ,  $P < .001$ ). Duncan's multiple-range test showed that black four-year students were significantly younger and white non-students significantly older than the other groups ( $P < .001$ ). Subjects from the black two-year college were well-matched with Ss from the white two-year college on age and education, but Blacks reported significantly fewer years of schooling for their fathers ( $df = 125$ ,  $P < .001$ ) than their white counterparts.

The POP score means for all four groups can be found in Table 1. An *F* test revealed highly significant differences ( $F = 20.87$ ,  $df = 3/372$ ,  $P < .001$ ) among groups. Individual *t* tests showed that both black samples scored significantly lower than the white student sample (both probabilities well beyond .001), the black two-year students scored significantly lower than the white non-students ( $P < .001$ ), black samples were significantly different from each other ( $P < .001$ ), and white samples also differed significantly from each other ( $P < .05$ ). When Ss from the white two-year school were matched on father's education with Ss from the black two-year school and the non-student Ss it became evident that race was still an important determinant of POP scores ( $F = 9.99$ ,  $df = 2/96$ ,  $P < .001$ ). Duncan's multiple-range test revealed that the two white samples were not significantly different from each other, but both scored significantly higher ( $P < .001$ ) than the black group.

The data generally support the hypothesis that Blacks are less inclined to favor population control than Whites. It is difficult to explain the significant differences between groups of the same race. Perhaps the difference between the black groups can be attributed to age or father's education, while age and father's education probably account for a large proportion of the difference between white groups. Maybe a greater desire for social change on the part of urban Blacks accounts for the difference between black groups while the white student group desired social change more than it's non-student counterpart. For Whites, it may be that a desire for social change results in higher POP scores, for the Blacks it may mean a rejection of white values, hence lower scores.

Blacks were much more inclined to agree that "population control is a plan to reduce the size of the black population." When scores on response categories indicating three levels of agreement with the statement were combined, Blacks from the two-year institution showed 49.1% agreement as compared with 6.41% agreement among white students and 2.7% among white non-students. Overall, the differ-

ence among groups on responses to this item was highly significant ( $F = 67.14$ ,  $df = 2/205$ ,  $P < .001$ ), with  $t$  tests showing that the black two-year students were significantly more likely to agree with the statement than both the white two-year students ( $P < .001$ ) and the white non-students ( $P < .001$ ). The two white groups did not differ significantly from each other.

In light of the fact that an earlier study found 28% agreement among Blacks that "Encouraging American blacks (sic) to use birth control is comparable to trying to eliminate this group from society" (Turner & Darity, 1971), the 49% agreement on a similar item is viewed as mildly surprising and possibly indicative of an increase in the fear of racial genocide.

The relationship between POP scores and scores on Attitudes Toward Blacks was  $-.25$  ( $df = 78$ ,  $P < .05$ ) for the two-year students and  $-.18$  ( $df = 72$ ,  $NS$ ) for the non-student sample. The possibility that scores on Attitudes Toward Blacks might have been influenced by social desirability was measured by giving Attitudes Toward Blacks and the Marlowe-Crowne Social Desirability Scale (1960) to 21 students from the predominantly white, two-year school. A correlation of .00 resulted, suggesting that at least for the white students there was no tendency to evaluate Blacks favorably because it was perceived as socially desirable to do so. For Blacks at the two-year school, the relationship between POP scores and scores on Attitudes Toward Whites was  $-.04$  ( $df = 55$ ,  $NS$ ).

If there were any widespread plot to eliminate Blacks, then one would expect to find that those who favor population control the most would also have an unfavorable attitude toward Blacks. The fact that the observed relationships, however weak, were in the opposite direction, further denies the validity of the idea that there is a general plan to eliminate the black population. Instead, the results are more consistent with the idea that those who advocate a change in the population growth rate also tend to prefer societal change for the benefit of minorities. On the other hand, these data do not dismiss the possibility that a handful of powerful people with racist views could instigate a policy of racial genocide under the guise of birth control services for the poor.

Table 3 shows that the overwhelming majority of Ss in all four groups expressed greater support for statements that indicate that population is a problem than for statements calling for immediate action. It should be noted that within-subject discrepancies were not extremely high for most Ss, but the data clearly support Barnett's (1970) contention that the population problem is abstractly perceived, and deny his prediction that by the mid-seventies this phenomenon would largely disappear. Furthermore, the opposite finding obtained by Fischer (1972) is probably the result of the overlapping nature of the items in his categories "concern about overpopulation" and "intention to have a small family." What Fischer apparently failed to consider is that intention to limit the size of one's own family, while important, is not the only way to accept personal responsibility for the population problem. Two other ways are to have only one or two children and adopt some, or to support governmental tax incentives for family size limita-

TABLE 3  
Comparison of subjects who did not perceive overpopulation as an abstract problem

Group comparisons	No. of Ss per group	% of Ss per group	Differences
Black two-year students/ black four-year students	3/2	5.3/3.0	2.3
Black two-year students/ white two-year students	3/8	5.3/10.0	-4.7
Black two-year students/ white non-students	3/7	5.3/9.5	-4.2
White non-students/ black four-year students	7/2	9.5/3	6.5**
White non-students/ white two-year students	7/8	9.5/10	-.5
Black four-year students/ white two-year students	2/8	3/10	-7*

\*  $P < .02$

\*\*  $P < .05$

tion. Fischer included items in his attitude inventory which tapped both of these; unfortunately, they both appeared under the "concern" rather than the "intention" category (p. 954). A third item under the "concern" heading, "It is a serious mistake to have a large family nowadays," at least implies the intention to limit one's own family (p. 954). With this kind of overlap it is not surprising that Fischer found relatively little abstract perception of the problem.

Table 3 shows that the proportion of Black four-year students who did not perceive overpopulation as an abstract problem was significantly lower than the proportion for both white groups. The other differences were nonsignificant but directionally consistent with the research hypothesis. Furthermore, a more powerful statistic, applied to abstraction index scores, revealed highly significant differences ( $F = 6.54$ ,  $df = 3/272$ ,  $P < .001$ ), which added further support to the research hypothesis. Individual  $t$  tests revealed that: black four-year students had significantly higher index scores than the white students ( $P < .001$ ) and the white non-students ( $P < .01$ ); black two-year students had significantly higher index scores than the white students ( $P < .01$ ) and the white non-students ( $P < .05$ ); the black groups were not significantly different from each other, and neither were the white groups.

It would appear, at least among educated Blacks of child-bearing age, that overpopulation is more likely to be perceived as an abstract problem than it is among young Whites. If the cause of the difference is a feeling of powerlessness, then less-educated Blacks might be expected to perceive the problem even more abstractly, since their lack of education would decrease the probability of ascendance to a position of power.

One weakness in the present study is the subjectivity involved in the selection of items for the abstraction index. This leaves open the possibility that subjects may have responded to the extremity of the statements as well as their substance. It means that the general finding that subjects tended to per-

ceive overpopulation abstractly is open to question, although it should not affect the racial comparison based on the index.

**Acknowledgments**—The authors wish to thank the following people for their cooperation: Larry Barnett, Eugene Fichter, Dean Haledjian, Jack Kennedy, Guy Lummis and Clinton Pettus.

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Manuscript received September 15, 1975

## Crystal Field Stabilization Energies: Weak and Strong Field Treatments

Several excellent papers dealing with various aspects of crystal field theory have been published by Carlin (1963), Zuckerman (1965), Kettle (1969), Krishnamurthy and Schaap (1970), Companion and Komarynsky (1964) and Cotton (1964), and there are a number of excellent treatments of CFT in standard textbooks for that subject such as Ballhausen (1966), Figgis (1966), Kettle (1969), Griffith (1961), and Orgel (1960). The reader who would like a mathematically non-rigorous introduction to CFT, however, sometimes must resort to oversimplified treatments which may lead to a misconception of the basic definition of crystal field splitting and an incomplete understanding of the meaning of weak and strong crystal fields.

A fundamental problem with many treatments of CFT is that only strong crystal fields are studied, and unfortunately the reader comes away with the idea that "orbitals" are always split as if they were in a strong field. As will be seen later, this erroneous belief not only limits one's understanding of crystal field splitting diagrams, but also leads to the (sometimes) incorrect calculation of crystal field stabilization energies in weak crystal fields.

When a crystal field acts on a metal ion it is necessary to consider the relative importance of the forces working *within* the metal ion and the forces working *on* the metal ion (crystal field). Assuming that Russell-Saunders coupling is less important than interelectronic repulsions and the crystal field potential, two extreme cases can be envisioned: (1) the crystal field forces are much weaker than the interelectronic repulsion forces (*weak field approximation*); (2) the crystal field forces are much stronger than the interelectronic repulsion forces (*strong field approximation*).

### Weak Field Limit

A free metal ion is under the influence of two major perturbations in the absence of a crystal field. The magnitude of these two perturbations must be compared with the magnitude of the cubic potential,  $V_c$ .<sup>1</sup>

The weak field limit can be defined as the case where

$$\zeta(r) \bar{T} \cdot \bar{S} < V_c < e^2/r_{12}.$$

The quantities  $\zeta(r) \bar{T} \cdot \bar{S}$  and  $e^2/r_{12}$  are the spin-orbit coupling term and the interelectronic repulsion term, respectively, arising from the expression for the free-ion Hamiltonian. If it is assumed that  $V_c$  is much smaller than the interelectronic repulsion energies, all that need be considered is how the various terms resulting from interelectronic repulsions are split by the crystal field. As an example of such a situation, consider a  $d^2$  system, e.g.  $Ti^{2+}$ . Because of interelectronic repulsions the two  $d$  electrons produce both singlet ( $S = 0$ ) terms and triplet ( $S = 1$ ) terms. In addition, S, P, D, F and G terms arise because of angular momenta coupling (Figure 1). From Hund's rule, the ground term is  $^3F$  (Table 1), which is split<sup>2</sup> by a weak crystal field according to Figure 2. It should be emphasized that the manner in which a given term splits in a crystal field is not dependent solely on the term itself, but also on the configuration from which the term is derived. For example, although both  $d^2$  and  $d^8$  configurations give rise to  $^3F$  terms (Table 1), the order of splitting of  $^3F(d^8)$  is inverted relative to the splitting in Figure 2. This can be easily understood by invoking the "hole formalism" concept. Since splitting of orbitals (or terms) in a crystal field comes about because of electrostatic repulsions, the crystal field would be expected to have exactly opposite effects on negative and positive charges. By considering a  $d^2$  system as two negative charges in the  $d$  orbitals and the  $d^8$  system as two positive charges (there are two "holes" not occupied by electrons), it is easy to see why the order of splitting for  $d^2$  and  $d^8$  is reversed.

Now that the splitting of  $F$  terms in crystal fields has been considered, it is appropriate to consider how other terms split in cubic fields. The appropriate splittings are listed in Table 2. Since free-ion terms are split by the crystal field, it is obvious that the

<sup>1</sup> In this paper, cubic refers to octahedral, tetrahedral or cubic geometries.

<sup>2</sup> Details concerning the origin and derivation of the splitting can be found in Ballhausen (1966) and Figgis (1966).

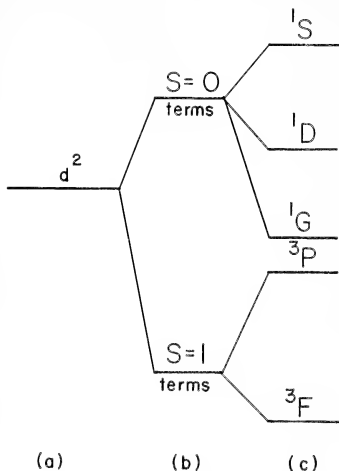


FIG. 1—Splitting of a  $d^2$  free-ion configuration (a) by spin (b) and orbital (c) angular momentum coupling.

quantum number  $L$  which is used to designate the free-ion terms can no longer be used to identify the levels which exist in the crystal field. For this reason, the levels listed in Table 2 are identified by group theoretical labels. It is sufficient at this point to note that levels labeled A (or B) are non-degenerate; E levels are doubly degenerate; levels labeled T are triply degenerate. Thus, the levels arising from  $^3F(d^2)$  in Fig. 2 can be labeled  $^3A_2$ ,  $^3T_1$  and  $^3T_2$ , at +12 Dq, +2 Dq and -6 Dq, respectively.

The difference in energy between the lowest level of a term in a crystal field and the baricenter (center of gravity) of the term in the crystal field is defined as the *Crystal Field Stabilization Energy* (CFSE). Although the CFSE is often used to explain relative

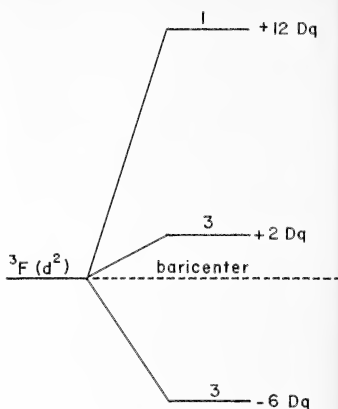


FIG. 2—Splitting of the  $^3F$  term (from  $d^2$ ) in an octahedral field. The number above each level indicates the orbital degeneracy.

stabilities of transition metal complexes, there are many other factors which determine the final energy of a transition metal complex, for example the bonding energy between the ligands and the metal, and interelectronic repulsions.<sup>3</sup> The CFSE can easily be determined once the splitting pattern for a given term is known. Thus, the CFSE for a  $d^2$  system in a weak octahedral field is -6 Dq (Fig. 2). Keeping in mind that the splitting for  $^3F(d^2)$  is the reverse of that in Figure 2, it is easily seen that the CFSE for a  $d^8$  ion in a weak octahedral field is -12 Dq. The crystal field stabilization energies for  $d^1 - d^9$  systems in weak

<sup>3</sup> Figures 2 and 3 represent only one aspect of the energy changes brought about by the metal-ligand interaction. As the negative ligands are brought toward the metal ion, the coulombic attraction causes a decrease in the energy of the system. As the ligands are brought closer to the metal, the negative ligands interact with all of the electrons of the metal, and the energy of the system is increased. Finally, the octahedral potential seen by the  $d$  electrons can be expressed as  $V_{oct} = (6 Ze^2/a) + (35 Ze^2/4a^3)(x^4 + y^4 + z^4 - 3/5 r^4)$  where the  $d$  electrons are at a distance  $a$  from the metal ion and have charges of magnitude  $-Ze$ . The first term is a spherically symmetric term and raises the energy of all of the  $d$  electrons (or energy terms derived from a given configuration) by the same amount. The second term is responsible for the splitting depicted in figures 2 and 3.

TABLE 1  
Terms Resulting from  $d^n$  Configurations (The Term Listed on the Far Left is the Ground Term).

Configuration	Resulting Terms
$d^1, d^9$	$^2D$
$d^2, d^8$	$^3F, ^3P, ^1G, ^1D, ^1S$
$d^3, d^7$	$^4F, ^4P, ^2H, ^2G, ^2F, ^2D, ^2P$
$d^4, d^6$	$^5D, ^3H, ^3G, ^3F, ^3D, ^3P, ^1I, ^2G, ^1F, ^2D, ^2S$
$d^5$	$^6S, ^4G, ^4F, ^4D, ^4P, ^4I, ^2H, ^2G, ^2F, ^3D, ^3P, ^2S$

TABLE 2  
Splittings of Terms by Cubic Fields

Orbital Degeneracy	Levels Arising in Cubic Fields
S	$A_1$
P	$T_1$
D	$E + T_2$
F	$A_2 + T_1 + T_2$
G	$A_1 + E + T_1 + T_2$
H	$E + T_1 + T_1 + T_2$

TABLE 3  
Ground Terms and CFSE Values for  $d^n$  Configurations  
in Weak  $O_h$  Fields

Configura- tion	Free-ion Ground Term	Ground Term in Weak $O_h$ Field	CFSE in Weak $O_h$ Field, $Dq$
$d^1$	$^2D$	$^2T_{2g}$	-4
$d^2$	$^3F$	$^3T_{1g}$	-6
$d^3$	$^4F$	$^4A_{1g}$	-12
$d^4$	$^5D$	$^5E_g$	-6
$d^5$	$^6S$	$^6A_{1g}$	0
$d^6$	$^5D$	$^5T_{2g}$	-4
$d^7$	$^4F$	$^4T_{1g}$	-6
$d^8$	$^3F$	$^3A_{2g}$	-12
$d^9$	$^2D$	$^2E_g$	-6

octahedral crystal fields are listed in Table 3. Since  $d^0$ ,  $d^5$  and  $d^{10}$  configurations give rise to free-ion S terms which are not split by the crystal field (Table 2), the CFSE for these three configurations is zero. It was previously mentioned that a very common error in some texts is the calculation of crystal field stabilization energies for transition metal ions in weak crystal fields. In particular, the CFSE for a  $d^2$  system in a weak octahedral field is often quoted as  $-8 Dq_0$  rather than the correct value of  $-6 Dq_0$ . Since, for a given stereochemistry, splitting diagrams for  $d^n$  and  $d^{n+5}$  configurations are the same, but reversed to the splittings for  $d^{10-n}$  and  $d^{5-n}$ , the same mistake often occurs for a  $d^7$  ion in a weak octahedral field. Similarly, it can be shown that  $d^3$  and  $d^8$  terms in weak tetrahedral fields split in the same manner as the terms arising from octahedral  $d^2$  and  $d^7$  configurations. Thus a discrepancy between the correct ( $-6 Dq_0$ ) and the often quoted CFSE ( $-8 Dq_0$ ) also exists. This situation is even more serious than the octahedral case since tetrahedral fields are almost always considered to be weak (recall that  $Dq_t = 4/9 Dq_0$ ). Thus, the erroneous value of  $-8 Dq_0$  would be more at variance with experimental results than in the octahedral case.

### Strong Field Limit

In the weak field approximation, it was assumed that the crystal field was of lower energy than the interelectronic repulsion forces. As a consequence, the crystal field acts as a perturbation on the free-ion terms, which are split into a series of levels. In the strong field approximation, however, the crystal field forces are more important than the interelectronic repulsions, i.e.,

$$V_c > e^2/r_{12} > \zeta(r) \vec{l} \cdot \vec{s}.$$

In other words, the L-S coupling in the free ion is completely destroyed by the much stronger forces exerted on the electrons by the crystal field. It is not appropriate, therefore, to speak of free-ion terms in a strong crystal field. Instead, strong field configurations should be considered. The d orbitals are split into two sets as in Figure 3. To take as an example the  $d^2$  case considered in the weak field treatment, we consider that the two d electrons do not interact with one another, but are assigned to the  $e_g$  or  $t_{2g}$  orbital sets. Since the  $t_{2g}$  set is at lower energy (Fig. 3), the

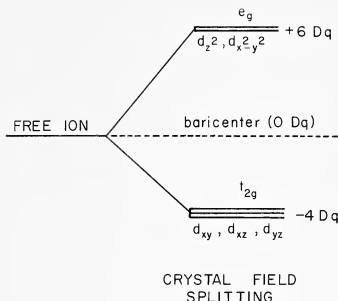


FIG. 3—Splitting of metal d electrons in an octahedral field.

ground state strong field configuration is  $t_{2g}^2$ , excited states being  $e_g t_{2g}^1$  and  $e_g^2$ . From Figure 3, it is easily seen that the CFSE for strong field configurations can be obtained by

$$CFSE_{Oh,S.F.} = (\#t_{2g} e^-)(-4 Dq)$$

Thus, the CFSE for  $d^2$  in a strong octahedral field is  $(2)(-4) = -8 Dq_0$  for the ground state. The excited  $d^2$  configurations  $t_{2g}^1 e_g^1$  and  $e_g^2$  give rise to CFSE values of  $+2 Dq_0$  and  $+12 Dq_0$ , respectively. Similarly, strong field  $d^7$  (octahedral) configurations will have a CFSE equal to  $-18 Dq_0$ , and strong field  $d^3$  and  $d^8$  (tetrahedral) configurations will have CFSE values of  $-18 Dq_t$  and  $-8 Dq_t$ , respectively.

### Weak to Strong Field Transition: Correlation Diagrams

Up to this point, the strong field case has been described only in terms of assigning electrons to  $t_{2g}$  and  $e_g$  orbital sets, without any concern for the ways in which the electrons might interact. It is reasonable to expect that strong field configurations might be split into terms by interelectronic repulsions, just as free-ion configurations are split into free-ion terms. An important point to note here, however, is that in the weak field case the crystal field was considered to act as a perturbation on the energies of the free-ion levels (i.e., the energy separation between free-ion levels is large compared to the crystal field splitting). In the strong field approximation, the crystal field splits the d orbitals into  $t_{2g}$  and  $e_g$  orbital sets the occupation of which can be described by strong-field configurations. The interelectronic repulsions, which are much weaker than the crystal field, then act as perturbations on the strong field configurations.

The assignment of strong-field terms for a  $d^1$  configuration is trivial, since there are no interelectronic repulsions. The ground state configuration for  $d^1$  is

$t_{2g}^{-1}$  (at  $-4 Dq_0$ ) in an octahedral field and the excited state ( $e_g^{-1}$ ) is at  $+6 Dq_0$ . These configurations correspond, respectively, to  ${}^2T_{2g}$  and  ${}^2E_g$  terms, the energies of which are the same at all values of  $Dq_0$ . Using the hole formalism concept, the ground term for  $d^1$ ,  $t_{2g}^6 e_g^{-1}$ , is immediately recognized as  ${}^2E_g$  in an octahedral field. The case of a  $d^2$  configuration is not trivial, and the effect of interelectronic repulsions on the splitting of strong field configurations must be considered. The three configurations to be considered are  $t_{2g}^2$ ,  $t_{2g}^1 e_g^{-1}$ , and  $e_g^2$ . A presentation of the methods for finding which terms result from a given strong field configuration is beyond the scope of this article, but can be found, for example, in Ballhausen (1966) and Figgis (1966). The terms resulting from a  $d^2$  configuration are shown in Table 4. The ground terms for strong field configurations can be determined by use of group theoretical arguments and are given in Table 5.

The transition from a weak to a strong field for  $d^2 - d^8$  configurations can be illustrated by means of a correlation diagram. This type of diagram is prepared by listing the free-ion terms and their splitting in weak fields on the left side, and the strong field configurations and their splitting in strong fields on the right side. Tie lines are then drawn from side to side, connecting terms of the same symmetry and multiplicity. The "non-crossing" rule states that tie lines joining energy levels which correspond to wavefunctions with the same symmetry labels may not cross (Figgis 1966). The correlation diagram for a  $d^2$  configuration is shown in Figure 4 (correlation diagrams for  $d^2 - d^8$  systems can be found in Figgis 1966). The consequence of the non-crossing rule is that the tie lines joining  ${}^3T_{1g}$  (from  ${}^3F$ ) and  ${}^3T_{1g}$  (from  ${}^3P$ ) do not cross. The ground term is the same ( ${}^3T_{1g}$ ) in both the weak and strong field approximations (compare Tables 3 and 5). Why, then, are the crystal field stabilization energies different in the two limits? In the weak field limit it was assumed that free-ion terms were separated by large energy differences and that consequently there was no interaction between them. In reality, however, there is a possibility for interaction between levels with the same symmetry labels and multiplicity, commonly known as configuration interaction.<sup>4</sup> As might be expected, the extent of interaction is dependent on the initial separation between the energy levels involved as well as the value of  $Dq$  (i.e., the strength of the crystal field). Referring to Figure 4, it can be seen that "configuration interaction" can take place between  ${}^3T_{1g}$  ( ${}^3F$ ) and  ${}^3T_{1g}$  ( ${}^3P$ ). This interaction is depicted in Figure 5. The value of

<sup>4</sup> "Configuration Interaction" is really a misnomer and actually describes interactions between energy levels, not configurations.

TABLE 4  
Splitting of Strong Field  $d^2$  Configurations  
by Interelectronic Repulsions

Strong Field Configuration	Resulting Terms (Listed in Order of Increasing Energy)
$t_{2g}^2$	${}^3T_1, {}^1T_2, {}^1E, {}^1A_1$
$t_{2g}^1 e_g^{-1}$	${}^3T_1, {}^3T_2, {}^1T_1, {}^1T_2$
$e_g^2$	${}^3A_2, {}^1E, {}^1A_1$

TABLE 5  
Ground Terms for  $d^n$  Configurations in Strong  $O_h$  Fields

Configuration	S. F. Configuration	Ground Term
$d^1$	$t_{2g}^1$	${}^2T_{2g}$
$d^2$	$t_{2g}^2$	${}^3T_{1g}$
$d^3$	$t_{2g}^3$	${}^4A_{2g}$
$d^4$	$t_{2g}^4$	${}^3T_{1g}$
$d^5$	$t_{2g}^5$	${}^2T_{1g}$
$d^6$	$t_{2g}^6$	${}^1A_{1g}$
$d^7$	$t_{2g}^6 e_g^{-1}$	${}^2E_g$
$d^8$	$t_{2g}^6 e_g^{-2}$	${}^3A_{2g}$
$d^9$	$t_{2g}^6 e_g^{-3}$	${}^2E_g$

$x$  is dependent on the extent of interaction between the  ${}^3T_{1g}(F)$  and  ${}^3T_{1g}(P)$  levels. Specifically,

$$2x = \langle {}^3T_{1g}(F) | V_{\text{oct}} | {}^3T_{1g}(P) \rangle \\ = \int \psi^{*3}T_{1g}(F) V_{\text{oct}} \psi^3T_{1g}(P) dx, \text{ where}$$

$\psi^3T_{1g}(F)$  and  $\psi^3T_{1g}(P)$  are the wave functions describing the unmixed  ${}^3T_{1g}(F)$  and  ${}^3T_{1g}(P)$  levels, respectively. The value of  $x$  reaches its maximum of  $2 Dq$  in the strong field case where the levels are interacting completely. This value, then, correctly predicts the energy values of the  ${}^3T_{1g}(P)$  and  ${}^3T_{1g}(F)$  levels in the

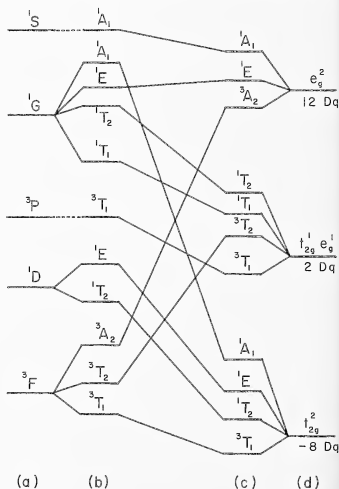


FIG. 4—Correlation diagram for an octahedral  $d^2$  configuration; (a) free-ion terms; (b) weak-field terms; (c) strong-field terms; (d) tetrahedral systems. The diagram is also applicable to  $d^8$  tetrahedral systems.



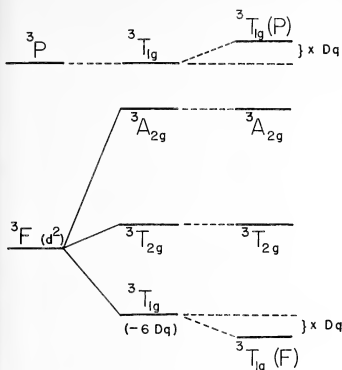


FIG. 5—Configuration interaction between  ${}^3T_{1g}(P)$  and  ${}^3T_{1g}(F)$  levels in an octahedral field.

strong field limit, viz.  $+2Dq$  and  $-8Dq$ , respectively. In the limit of the weak field,  $x = 0Dq$  and the energies of the  ${}^3T_{1g}(P)$  and  ${}^3T_{1g}(F)$  levels are  $15B$  and  $-6Dq$ , respectively.<sup>5</sup> Since the splitting for a  $d^3$  or  $d^8$  ion in a tetrahedral field is identical to the splitting of a  $d^2$  ion in an octahedral field, identical arguments apply to these cases, as well as the  $d^7$  octahedral case. Of course, the same type of configuration interaction occurs for  $d^2$ ,  $d^7$  tetrahedral and  $d^3$ ,  $d^8$  octahedral cases, but now the  $T_1(F)$  level which is involved in configuration interaction is not the level of lowest energy and is not involved in the calculation of

CFSE. Thus, there is no discrepancy between CFSE values calculated in weak and strong fields for these cases.

In conclusion, it has been shown that the treatments of crystal field theory in the weak and strong field limits come about by the application of logical assumptions which are implicit in the definitions of the two limits. The origin of apparent differences in the values of crystal field stabilization energies calculated for the two limits can be explained by the simple and easily understood concept of "configuration interaction".

Although it is somewhat difficult to cover all of the basics of crystal field theory in an article such as this, it is hoped that the reader comes away with an appreciation of both the inherent similarities and necessary differences between the weak and strong field treatments of CFT.

*Acknowledgment*—The authors thank Dr. John C. Schug for helpful discussions during the preparation of this manuscript.

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Manuscript received December 4, 1975

## The Mammals of Presquile, Chesterfield County, Virginia

**Abstract**—On the basis of captures, sightings and analyses of remains in barn owl pellets, 22 species of mammals exclusive of bats are known to occur on Presquile National Wildlife Refuge, Chesterfield County, Virginia. Diversity was greatest in the edge-like fill community, followed by escarpment, swamp and cultivated fields, respectively. Based on captures, the most abundant mammals are the cotton mouse, *Peromyscus gossypinus*, house mouse, *Mus musculus*, hispid cotton rat, *Sigmodon hispidus*, rice rat, *Oryzomys palustris*, short-tailed shrew, *Blarina brevicauda*, and eastern meadow vole, *Microtus pennsylvanicus*. The white-tailed deer, *Odocoileus virginianus* is also abundant.

### Introduction

The distributional status of mammals in many areas of Virginia reflects not only native patterns and implied biotic and abiotic parameters, but also the actions of man in the last two hundred years in destroying, modifying, creating and maintaining suitable areas. One such area that has long been influenced by man is Presquile, a man-made island in the James River in the northeastern corner of Chesterfield County just south of Charles City and Henrico Counties, Virginia. The 1329 acre "almost island" on the south side of the James River became an island in 1934 when the U.S. Army Corps of Engineers channeled through the neck of an ox-bow bend in the river. Presquile is approximately 12 miles downstream from the City of Richmond, and within sight of the industrial City of Hopewell. Presquile is near some of the oldest plantations in the state, including Curles Neck and Shirley and the community of Bermuda Hundred. Presquile became a National Wildlife Refuge in 1952.

Parker and Wyatt (1975) recognized five plant communities at Presquile. (1) The major portion of the island (800 acres) is swamp that is subject to partial inundation during high tide and total inundation in river flooding. Much of the swamp floor is covered with fallen trees, stumps, exposed root systems and flotsam. Vegetation in the swamp includes ash, *Fraxinus* spp., tupelo gum, *Nyssa aquatica*, black gum, *N. sylvatica*, and scattered stands of

bald cypress, *Taxodium distichum*, and the single understory tree, ironwood, *Carpinus caroliniana*, is abundant throughout the community. (2) Two tidal marshes that are inundated by high tides together comprise 250 acres of the island surface. The community is dominated by herbaceous plants that include arrow-arum, *Peltandra virginica*, arrowhead, *Sagittaria* spp., Wild rice, *Zizania aquatica*, and common cat-tail, *Typha latifolia*. (3) Approximately 250 acres of the island is seeded for use for agriculture and/or waterfowl. The only relatively stable portions of the field area are the field borders. These are dominated by grasses and weedy herbaceous species. (4) A relatively steep escarpment that is for the most part covered by trees and undergrowth borders the entire cultivated area. Trees along the escarpment include hackberry, *Celtis laevigata*, red cedar, *Juniperus virginiana*, chestnut oak, *Quercus prinus*, Spanish oak, *Q. falcata*, hickory, *Carya* spp., and winged elm, *Ulmus alata*. Undercover along the escarpment includes Japanese honeysuckle, *Lonicera japonica*, leather flower, *Clematis viorna*, trumpet creeper, *Campsis radicans*, grape, *Vitis* spp., and greenbrier, *Smilax* spp. (5) Approximately 50 acres of the island were covered by material dredged from the navigation channel during formation of the island in 1934. As a result of differences in elevation and various features of the soil this small area contains the most varied plant species. Higher areas inland in the fill area are covered with low grasses, mixed with blackberry, *Rubus* spp., interspersed with isolated stands of *Juniperus virginiana* and black locust, *Robinia pseudoacacia*. Near the river the fill area contains a mixture of sycamore, *Platanus occidentalis*; red maple, *Acer rubrum*, cottonwood, *Populus deltoides*, and tulip tree, *Liriodendron tulipifera*, with little under cover except for river debris. Some sites within the fill area are bare. In addition to their observations of vegetation of Presquile, Parker and Wyatt discuss topography, climate, and edaphics of the island.

The purpose of our study was to determine the kinds and relative abundance of mammals, exclusive of bats, in each of the communities of Presquile. The information should be useful in the future in eval-

uating the effect on small mammals of management practices on non-cultivated portions of the refuge and stresses placed on the island by a growing industrial-metropolitan area.

### Methods and Materials

We made trapping collections weekly in the months of January through March, 1974 and a final collection in August, 1974. Snapback mouse traps baited with a mixture of peanut butter and rolled oats were used in all collections. Traps were set singly along temporary transects at intervals of 10 to 15 m. In the swamp, circular traplines above high tide levels were set as dictated by sites for landing our boat. We were not able to trap in the tidal marsh, because the pronounced changes in water level resulted in the lack of sites for trap placement. The amount of trapping effort, described here in terms of trap nights, is presented in Table 1. A trap night refers to the period of time from setting until check or pickup of a trap. In most instances this was 8 to 12 hours.

Barn owl pellets were collected from a silo on Presquile on 23 January, 12 February and 9 April, 1974, and 19 April, 1975. Each pellet was placed individually in a plastic bag at the time of collection and crania were extracted in the laboratory. Several hundred crania were isolated from disintegrated pellets that had accumulated on the floor of the silo. Sight records, tracks, feces and skeletal remains were used to supplement information obtained from owl pellets and trapping.

Diversity was calculated by the Loyd, Zarr, and Karr (1968) formula for the Shannon-Weaver Index. This is  $H' = 1/N (N \log_{10} N - \sum n_i \log_{10} n_i)$ , where  $N$  is the total population and  $n_i$  the number of species  $i$ .

### Results and Discussion

A list of the species of mammals that we found on Presquile National Wildlife Refuge is presented in Table 1. No species now considered rare or endangered were noted.

The diversity of mammals captured in the fill area indicates a greater habitat diversity in that community (Table 1). The fill community contained 61.3 per cent of all species seen or captured. Only the ubiquitous house mouse and white-tailed deer were in all communities sampled. Six of 22 species were in three of the four communities. The distributions of two of the six, *O. palustris* and *O. zibethicus*, are closely associated with water, a prominent feature of much of Presquile. The other four, *D. virginiana*, *P. lotor*, *M. mephitis* and *V. vulpes*, all are known to have large home ranges that may include several types of habitat. We found three red fox dens on the island, each in a different community. A den along the escarpment contained pups in spring 1974 and remains of muskrat, cottontails, several birds and fish were evident around it.

The beaver, *C. canadensis*, may not now occur on Presquile; only old signs were noticed. Several gnawed and fallen trees are evident near the river in the northeast section of the swamp and there are active colonies of beaver on the shore of the James River opposite this site.

The white-tailed deer, *O. virginianus*, is abundant

on the island. The herd size has averaged about 200 deer in the past few years (H. Olson, personal communication), and each year the herd is cropped during a controlled hunt. We have seen deer and signs of deer on all parts of Presquile. Primary bedding areas include the tall *Equisetum* on the edge of the east marsh and two grassy clearings and scattered hammocks within the swamp.

Small mammals whose presence was detected only by their remains in owl pellets were *C. parva* and *R. humilis*. Remains of two *S. aquaticus* were found in owl pellets, and shallow uplifted feeding burrows of moles were evident in parts of the field and fill areas.

*Microtus pennsylvanicus*, *O. palustris*, and *M. musculus* together comprised 81.4 per cent of the prey items of the Barn Owl. Comparisons of mammals captured and those present in owl pellets suggest that the owl foraged little in the swamp (Table 1). Evidently it hunted mostly in fields and marsh edges. Trapping indicated that *P. gossypinus* is abundant in the swamp, but no pellets contained remains of cotton mice. Several disintegrated pellets found in the middle of the swamp under an old, temporarily used roost of an unidentified owl contained remains of several short-tailed shrews, pine voles and meadow voles. None of these were trapped in the swamp and they presumably do not occur there. Presquile is very near the northernmost location for *P. gossypinus* on the east coast (Ulmer 1963). Ulmer collected a cotton mouse on the edge of a swampy riverbottom woods approximately five miles south of Presquile along the Appomattox River. The white-footed mouse, *Peromyscus leucopus*, is the most common Virginia mammal (Handley and Patton 1947) but none were taken at Presquile. Suitable habitat is available for *P. leucopus* and its absence may be the result of competition with *P. gossypinus* (See Baker 1968; McCarley 1963).

Although the barn owl may have foraged in part away from the island, the difference in numbers of *M. pennsylvanicus* captured in traps and isolated from owl pellets likely reflects long range and seasonal differences in abundance of meadow voles on Presquile. Meadow voles comprised 63.7 per cent of the prey items isolated from disintegrated owl pellets. In the January and February 1974 collection of owl pellets, meadow voles made up less than 20 per cent of the prey items, but in the April 1974 collection meadow voles comprised 62 per cent of the prey items. In the April 1975 collection, meadow voles comprised 68.8 per cent of the prey items in whole pellets and 68.0 per cent of the items in disintegrated pellets. Meadow voles are known to be important prey of barn owls (see Blem and Pagels 1973). Our data suggest a low meadow vole population at the beginning of the study followed by a rapid increase in early spring, 1974.

The hispid cotton rat is apparently a recent arrival to Presquile. *Sigmodon hispidus* was unknown from Virginia until 1941 (Patton 1941) and Presquile is only eight miles south of the present northernmost site for *Sigmodon* in Virginia (Pagels and Adelman 1971).

In summary, Presquile has more than half of the terrestrial species of mammals known to occur in Virginia (Handley and Patton 1947), exclusive of bats

TABLE 1

Species of mammals on Presquale National Wildlife Refuge. Numbers represent numbers of mammals captured or crania removed from barn owl pellets. Letter (S) designates sign or sightings. Numbers in parentheses designate trap nights in each area.

Species	Crania in Owl Pellets	Captures—Community			
		Swamp	Field	Fill	Escarpment
		(1103)	(467)	(656)	(233)
<i>Didelphis virginiana</i> opossum		S		S	S
<i>Blarina brevicauda</i> short-tailed shrew	70		1	8	
<i>Cryptotis parva</i> least shrew	5				
<i>Scalopus aquaticus</i> common mole	2		S	S	
<i>Sylvilagus floridanus</i> e. cottontail	2		S	S	
<i>Marmota monax</i> woodchuck					S
<i>Sciurus carolinensis</i> e. gray squirrel		S			S
<i>Castor canadensis</i> beaver		S			S
<i>Oryzomys palustris</i> rice rat	148	6		5	1
<i>Signodon hispidus</i> hispid cotton rat	50		2	25	
<i>Reithrodontomys humalis</i> e. harvest mouse	8				
<i>Peromyscus gossypinus</i> cotton mouse		85			14
<i>Microtus pennsylvanicus</i> e. meadow vole	696			8	
<i>Pitymys pinetorum</i> pine vole	35			1	
<i>Ondatra zibethicus</i> muskrat		S		S	S
<i>Rattus norvegicus</i> Norway rat	40		S		
<i>Mus musculus</i> house mouse	129	14	28	7	26
<i>Vulpes vulpes</i> red fox			S	S	S
<i>Procyon lotor</i> raccoon		S		S	S
<i>Mustela vison</i> mink		S			
<i>Mephitis mephitis</i> striped skunk			S	S	S
<i>Odocoileus virginianus</i> white-tailed deer		S	S	S	S
Totals	1185	105	31	54	41
Diversity (H')		0.60	0.38	1.48	0.75
Captures/100 trap nights		9.5	6.6	8.2	17.6
			9.4		

and species confined to mountainous areas of western Virginia. None of these species is near its southern limit, but the rice rat, cotton rat and cotton mouse provide noticeable southern elements that are near the northern extent of their range. Nearly 60 per cent of the island is swamp, but only the mink and beaver were restricted to the swamp. Eight of the other 20 species, however, including most large forms, were observed or captured in the swamp as well as in other areas, suggesting the importance of the large swamp community to mammals present on the island.

Man's influence in providing suitable habitat for certain small species is demonstrated in captures in the fill and field communities. Six species, all usually considered edge or field forms, including the cottontail, meadow vole and cotton rat, were taken only in these communities.

*Acknowledgments*—We are grateful to the personnel of Presquile National Wildlife Refuge, especially Harold C. Olson, Refuge Manager, for the numerous considerations provided us during the study. Ms. Alice Pennington assisted in the collection of animals. We thank Dr. Charles R. Blem for reading the manuscript and the

use of his computer program for calculating diversity. Dr. Charles O. Handley, Jr. kindly examined specimens of *Blarina* and *Peromyscus*.

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Manuscript received April 2, 1976

## Semen Volume, Insemination Frequency and Initial Fertility of Turkey Breeders

**Abstract**—Experiments were designed to determine the effects of semen dosage and insemination frequency on fertility in young Medium White breeder turkeys. Treatments consisted of semen dosages of 0.025 or 0.05 cc of pooled semen and insemination frequencies of once, twice or three times at three-day intervals beginning immediately after the start of egg production. Semen dosage effects were variably significant depending upon the time after insemination. Single inseminations gave significantly lower fertility than multiple inseminations. There were no significant differences between hens inseminated two or three times, however, indicating that dual inseminations at close time intervals were adequate to assure optimum fertility during the initial phases of the egg production cycle. When the hens were re-impregnated with a single insemination, significant decreases in fertility were not detected until four weeks later. Based on these results, the common commercial practice of inseminating turkeys every seven to ten days during the early phases of the egg production cycle must be questioned.

### Introduction

There has been much disagreement about the conduct of artificial insemination (AI) in turkeys. For example, frequency of insemination (Lorenz 1950; McCartney 1952; Brown 1974; Van Krey et al. 1976), optimum semen dosage (Parker 1946; Lorenz 1950; McCartney 1952, 1954; Brown 1974), depth of insemination (Biellier et al. 1961; Ogasawara and Fuqua 1972; Wentworth et al. 1975), and the best time of day for inseminating (Wyne et al. 1959; Christensen and Johnson 1975) have all been debated at one time or another.

Despite the numerous differences of opinion regarding insemination practices, a degree of accordance persists among commercial turkey breeders and multipliers regarding AI during the period of time associated with the initiation of egg production. The current commercial practice is for hens to be inseminated three times in succession at intervals of three or four days. This practice is based on the high level of mating activity normally shown by females just before attaining sexual maturity, and on the relatively poor flock fertility occasionally associated with the start of egg production.

An additional associated problem plaguing some

turkey breeders and multipliers is chronic low fertility. This problem, however, is primarily the result of poor AI practices, usually by inferior inseminating crews. To overcome this, such flocks are being inseminated at 7–10 day intervals throughout the production year.

The purposes of the current experiments were to compare the effects of single and multiple inseminations and to test the effect of varying semen volume on the initial fertility of turkey breeder hens. In a related second phase of the experiments, the tenored levels of fertility were established following a single insemination as an aid in determining a logical frequency of insemination during the early phases of the egg production cycle.

### Methods

Duplicate, sequential experiments utilizing Medium White turkeys in a factorial arrangement of treatments were set up as outlined in Table 1. During the growing period and before the start of the experiment, the poults were subjected to standard management practices. At 24 weeks of age the hens were moved into a blackout house for a period of eight weeks. They were then moved into the experimental pens and exposed to a stimulatory lighting regimen consisting of a combination of 16 hours natural and artificial light per day. The minimum light intensity was 81.6 luxes. Males were managed in a similar manner but were subjected to the lighting regimen four weeks prior to the females. Experiment I was conducted during the winter (January–February) and Experiment II during the summer months (June–July) of 1974.

The hens were first inseminated when egg production had progressed to a flock average of approximately 10%. The semen was collected from males that were contemporaries of the females utilized in each of the experiments. All inseminations were made with pooled semen samples in an effort to minimize individual male effects. The initial sequential series of inseminations were made at three day intervals and the insemination frequency was either once, twice, or three times (Table 1). A second insemination of either 0.025 or 0.05 cc. of semen was made two weeks after

TABLE 1

Frequency of insemination, semen volumes, and number of birds by replicate and experiment

Times Inseminated	Semen Volume (cc)	Experiment 1		Experiment 2	
		Rep. 1	Rep. 2	Rep. 1	Rep. 2
One	.025	10*	10	8	8
	.050	10	10	8	8
Two	.025	10	10	8	8
	.050	10	10	8	8
Three	.025	10	10	8	8
	.050	10	10	8	8
Total		60	60	48	48

\* Number of birds.

the terminal insemination of the initial series.

Only fertility data are reported in these experiments. Hatchability data were not collected. The fertility data represent all obviously fertile eggs as judged by candling, along with a breakout and macroscopic examination of all other blastodiscs.

Data were summarized and the percentages were transformed to arc sine  $\sqrt{\%}$  before being analyzed by analyses of variance. Where appropriate, the treat-

ment effects associated with insemination frequency were subjected to orthogonal contrast analyses.

### Results and Discussion

When unequal numbers of inseminations are made, as in these experiments, it becomes difficult to make direct comparisons between data from the various treatment groups. The bases for comparisons are never equal in all respects. For that reason, the fertility data in these experiments have been reported in two different, yet related ways. First, fertility levels were calculated for the seven, ten, and fourteen-day intervals after the *initial* insemination of a series, without regard to the insemination frequency. Thus, while the same calendar days were being compared among treatment groups, there was an overlapping of days with subsequent inseminations.

The second way in which fertility levels were calculated was for the seven, ten, and fourteen-day intervals after the *last* insemination of a series. Thus, similar intervals were compared, but the calendar days being compared were not identical.

Fertility levels for equal time intervals after the initial AI are shown in Table 2, with the analysis of variance presented in Table 3. No significant differences were observed for any of the main variables. A

TABLE 2

Mean percentage fertility seven, ten, and fourteen days after an insemination summarized by experiment, replicate, semen dosage, and frequency of insemination.

Treatment		Percentage Fertility					
		After Initial Insemination			After Last Insemination		
		7 days	10 days	14 days	7 days	10 days	14 days
Experiment	1	89.2	91.4	92.2	93.3	93.6	93.7
	2	88.9	91.1	92.4	93.7	94.6	94.6
Replicate	1	89.3	91.3	92.2	93.2	94.4	94.8
	2	88.8	91.2	92.5	93.9	93.7	93.5
Dosage	.025 cc	86.6	89.8	91.2	91.6	92.3	92.5 <sup>a</sup>
	.05 cc	91.6	92.7	93.5	95.5	95.8	95.8 <sup>b</sup>
A.I. Frequency	1	87.6	90.1	89.5	87.6 <sup>a</sup>	90.1	89.5 <sup>a</sup>
	2	88.6	91.0	93.4	96.3 <sup>b</sup>	96.0	96.1 <sup>b</sup>
	3	91.0	92.6	94.1	96.7 <sup>b</sup>	96.1	96.9 <sup>b</sup>
Experimental Mean		89.5	91.3	92.3	93.5	94.1	94.2

Any two means within a treatment on the vertical which do not have the same superscript are significantly different.

TABLE 3

Analyses of variance<sup>1</sup> of the percentage fertility seven, ten, and fourteen days after an insemination

Source of variation		Mean Squares					
		After Initial Insemination			After Last Insemination		
		7 days	10 days	14 days	7 days	10 days	14 days
Experiment	1	0.9	0.1	1.8	6.3	7.9	1.7
Replicate	1	26.3	12.5	2.2	29.1	79.0	88.0
Dosage (D)	1	141.2	80.7	20.1	73.6	138.9	116.0*
A.I. Frequency (F)	2	8.3	5.4	64.7	303.1*	139.1	224.2**
D X F	2	168.7	119.6	125.7*	296.0*	158.4*	79.3
Error	16	56.2	40.5	28.1	66.6	40.8	22.9

<sup>1</sup> ANOVA on arc sine  $\sqrt{\%}$  transformations.

\*  $P \leq .05$ .

\*\*  $P \leq .01$ .

significant interaction of dosage  $\times$  insemination frequency was found at 14 days, but not at 7 or 10 days. This would be expected because of the overlapping of days and inseminations as described earlier.

When the time intervals selected for comparison were those after the terminal insemination of a series, significant semen dosage and AI frequency effects were observed (Tables 2 and 3). If the results summarized in Table 2 are interpreted as a unit, several interesting facts become evident. The data presented in the first part of Table 2 suggest that if the initial insemination of a young turkey hen is properly executed, a single insemination should be adequate. Nevertheless, as shown in the latter half of the table, a second insemination increased fertility significantly. This might appear to be contradictory, but it merely reflects the different time intervals being represented. The tabular differences should also serve to emphasize that in any AI program not all hens will be ideally impregnated after each insemination, and that subsequent inseminations will function to alleviate or correct the errors of the inseminating technicians. When viewed in their total context, the fertility data indicate that while more than one AI is desirable, more than two inseminations are unwarranted and unnecessary.

Commercial operators, when questioned on AI of turkeys just starting egg production, believed that saturation of the oviduct with spermatozoa was necessary to insure high initial levels of fertility. As mentioned, this concept was predicated upon the elevated mating activity seen in naturally mated hens at the time of sexual maturity, and also upon the poor fertility levels seen occasionally in new laying flocks. Biologically, however, neither reason is valid. The increased mating activity observed in naturally mated hens is, of course, merely the expression of a behaviorally oriented fitness trait which is related to the increasing ovarian estrogen output. With regard to the relatively poor fertility very early in the production year, it must be remembered that in commercial flocks fertility is based on flock averages, which do not necessarily reflect the fact that much of the fertility problem stems from some hens not being impreg-

nated until after attaining sexual maturity. Thus, dual inseminations, spaced at relatively close intervals, should allow the maximum expression of fertility in young turkey hens initiating egg production.

As indicated earlier, many commercial turkey flocks are currently being inseminated at seven or ten-day intervals. Based on data appearing in the literature, such AI frequencies might be considered excessive, (Lorenz 1950; McCartney 1954; Brown 1974; Van Krey et al. 1976). To re-examine the validity of earlier established insemination concepts and practices, the hens were re-inseminated once with either 0.025 or 0.05 cc. of semen two weeks after the last insemination and fertility data were collected for five consecutive weeks thereafter. Again the data were reported in two different ways, on a cumulative and on a non-cumulative basis. This was done because of the interdependence of the weekly data, i.e., the fertility level during any particular week is predicated in part upon the fertility level during the preceding week.

When examined on a cumulative basis, fertility remained exceedingly high for an extended period of time (Table 4). Fertility levels did not drop below 90% until the fifth week after insemination. To demonstrate that the previous experimental treatment had no residual effect on this phase of the study, the variable, insemination frequency, was included in the analyses (Table 5).

When summarized non-cumulatively, the fertility levels did not show a significant decline until the fourth week after insemination (Table 6). Based on these results, it is extremely doubtful that an AI interval of 7 to 10 days during the early phases of the egg production year is warranted. Conceivably, if economics dictated, the AI interval might even be extended beyond the normal 14-day interval early in the egg production year. Brown (1974) found that bi-weekly inseminations of virgin turkeys after 16 weeks of egg production yielded good fertility. Thus, both of these sets of data are in basic agreement with earlier experimental results (Lorenz 1950; McCartney 1954). The data also serve to emphasize that much of the erstwhile reproductive data are still applicable to

TABLE 4  
Mean cumulative weekly fertility after an insemination, summarized by experiment, replicate, semen dosage, and frequency of insemination (Experiments 1 and 2)

Treatment		Percent Fertility					
		7 days	10 days	14 days	21 days	28 days	35 days
Experiment Number	1	97.1	96.9	96.5	95.7 <sup>b</sup>	92.7 <sup>b</sup>	86.8 <sup>a</sup>
	2	97.4	96.9	96.2	93.2 <sup>a</sup>	87.9 <sup>a</sup>	80.6
Replicate	1	97.6	97.2	96.2	94.2	89.7	83.3
	2	96.9	96.7	96.4	94.6	91.0	84.1
Dosage	.025 cc	95.9 <sup>a</sup>	96.0	95.2 <sup>a</sup>	93.1 <sup>a</sup>	89.0	83.1
	.05 cc	98.6 <sup>b</sup>	97.8	97.4 <sup>b</sup>	95.7 <sup>b</sup>	91.7	84.3
AI Frequency	1	96.5	96.4	95.1	93.0	90.0	84.4
	2	98.1	97.3	96.6	95.4	90.7	83.2
	3	97.1	97.1	97.2	94.6	90.2	83.5
Experimental Mean		97.3	96.9	96.3	94.4	90.3	83.7

Any two means within a treatment on the vertical which do not have the same superscript are significantly different.



TABLE 5  
*Analyses of variance<sup>1</sup> of the weekly cumulative percentage fertility after an insemination (Experiments 1 and 2)*

Source of Variation	d.f.	Mean Squares					
		7 days	10 days	14 days	21 days	28 days	35 days
Experiment	1	10.2	11.9	2.8	60.5*	130.8**	144.5**
Replicate	1	5.9	8.1	27.1	3.1	11.0	2.3
Dosage (D)	1	244.2*	139.7	124.9*	67.7*	34.9	2.8
A.I. Frequency (F)	2	28.0	7.2	32.9	18.8	0.9	2.9
D X F	2	45.6	35.1	15.8	0.4	11.3	3.4
Error	16	37.5	37.6	21.9	9.4	10.2	14.2

<sup>1</sup> ANOVA on arc sine  $\sqrt{\%}$  transformations.

\*  $P \leq .05$ .

\*\*  $P \leq .01$ .

TABLE 6  
*Mean<sup>1</sup> non-cumulative fertility at weekly intervals after insemination by semen dosage treatments (Experiments 1 and 2 combined)*

Semen Dosage	Percentage Fertility by Week				
	1	2	3	4	5
0.025	95.9 <sup>a</sup>	94.6 <sup>a</sup>	87.3 <sup>a</sup>	74.1 <sup>b</sup>	56.7 <sup>c</sup>
0.05	98.6 <sup>a</sup>	96.3 <sup>a</sup>	92.6 <sup>a</sup>	76.3 <sup>b</sup>	46.3 <sup>c</sup>

<sup>1</sup> Means within each semen dosage treatment with different superscripts are significantly different from each other ( $P \leq 0.05$ ).

neoteric turkeys.

The semen dosage data are interesting. A standard dose of semen (0.025 cc.) presumably contains more spermatozoa than are necessary for maximum fertility (Parker 1946; Lorenz 1950; McCartney 1954; Brown 1974). Nevertheless, in our experiments the larger semen volumes consistently showed trends toward higher fertility levels, and in a number of instances the larger semen volume gave significantly higher fertility (Table 4). A cursory review of the literature reveals similar trends both in related experiments and in other avian species. The significance of this and its explanation are open to speculation, but most likely they are related to the retention of a critical number of spermatozoa.

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## News and Notes

### VAS Delegation to the AAAS Annual Meeting, Boston, February 21-24, 1976

The Academy was represented by E. L. Wisman and J. L. Hess and the Junior Academy by two student representatives, Ursula Schwebbs and Robert Baldwin, both of Arlington, who gave papers at the meeting of the American Junior Academy of Science.

### Spring Council Meeting of the Academy, Fairfax, March 20, 1976

The following Fellows of the Academy were elected:

Dr. Miles E. Hench, Medical College of Virginia  
Mr. Franklin D. Kizer, State Department of Education  
Dr. Russell J. Rowlett, Jr., Editor of Chemical Abstracts.

The following were elected Honorary Life Members of the Academy:

Lena Artz (Teacher, and a student of the Virginia flora in the Massanutten region)  
Lloyd C. Bird (President, 1952-53)  
John C. Forbes (President, 1958-59)  
Boyd Harshbarger (President, 1949-50)  
Roscoe D. Hughes (President, 1965-66)  
George W. Jeffers (President, 1941-42)  
I. D. Wilson (President, 1931-32)

### Research Committee

The Research Committee of the Academy has a modest amount of funding for a small number of grants. Members of the V.A.S. from any discipline may submit proposals. Although most recent grants have been in the area of biology, proposals from other areas would be welcomed by the Committee.

The Committee also seeks donors to contribute financially to the funds that the Academy has available for research grants.

The present chairman of the Committee is Dr. Rogers C. Ritter, Department of Physics, University of Virginia, Charlottesville, VA 22901.

### Recent Deaths

Two members of the Virginia Academy of Science have died in recent months: Morris W. Alexander, Extension Soybean Specialist at the Holland Station and member of the Section of Agricultural Sciences, on December 15, 1975; and Hiram R. Hanmer, retired vice president of the Department of Research and Development of the American Tobacco Company, on March 25, 1976. Mr. Hanmer was president of the Academy in 1945-46. He was a research chemist with the Company from 1921 on and retired in 1964.

As we go to press we have received word of the death of Roscoe D. Hughes, a long-time member of the Academy, former President (1965-66), Fellow (since 1970) and recipient of the Ivey F. Lewis Distinguished Service Award (1970). Dr. Hughes died on April 19, 1976.

### Financial Assistance for using Facilities Unavailable on your Campus

A small grants program, funded by the Alfred P. Sloan Foundation, enables faculty and Ph.D. students in the natural sciences in Southern colleges and universities to obtain support for expenses incurred while traveling to use equipment and facilities not available on their own campuses.

Numerous facilities which might be used through this program are listed in the Catalog of Uncommon Facilities in Southern Universities, a publication of the Southern Regional Education Board (SREB). However, support is not restricted to use of facilities listed in that document.

Funding will be given primarily for activities which enhance the learning process or have a direct relationship to a particular course of study. A faculty member could travel to another university to use a nuclear reactor to conduct irradiation experiments. Another faculty member might use a large-core computer for modeling and data analysis. A graduate student in geology could use one of the few geochronology laboratories in the region to examine and date samples he has collected.

The grants will cover expenses which result from the use of facilities, in particular living and travel expenses and charges that might be assessed for using the facilities. Requests which attempt to keep costs to a minimum will be received most favorably in an effort to insure wide distribution of the funds.

The procedure to be used in applying for a grant is as follows:

1. Contact the appropriate official at the institution holding the facility to explain the desired use of the facility and to arrange possible dates for a visit.
2. Apply to the project director at SREB for financial support. Indicate in the application letter the name and location of the facility to be visited, the educational purposes for using the facility, and estimated costs for transportation, living expenses, and use of the facility. Correspondence should be addressed to:

Dr. Steven H. Smartt  
Southern Regional Education Board  
130 Sixth Street, N.W.  
Atlanta, Georgia 30313

With the application letter, enclose an endorsement from a school official. (Student travel should be endorsed by the student's faculty advisor. Faculty travel should be endorsed by the department chairman.)

All grant requests will be acted upon within three weeks of the date received. In approving an application, SREB will agree to reimburse the user for expenditures not to exceed a specific amount, based on the estimated costs. Reimbursement will be made upon receipt of an itemized expense account and a letter describing the experience and the extent to which the proposed objectives were accomplished.

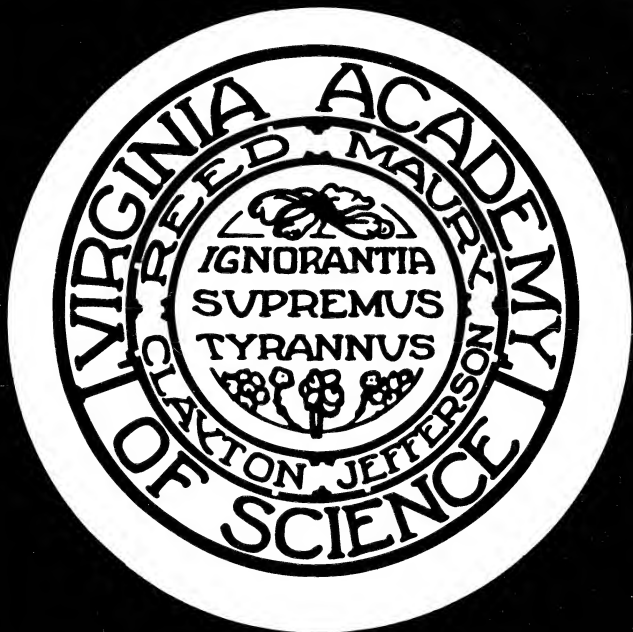




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# VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE



VOL. 27, NO. 2

SUMMER 1976



# VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE  
VIRGINIA ACADEMY OF SCIENCE

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# THE VIRGINIA JOURNAL OF SCIENCE

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Published quarterly by The Virginia Academy of Science, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Second-class postage paid at Richmond, Virginia.

Manuscripts for publication (other than section abstracts) should be sent to the Editor, Dr. David A. West, Department of Biology, V.P.I. and S.U., Blacksburg, Virginia 24061. Proof, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

Advertising and Business Office: All correspondence relating to advertising and business affairs should be directed to Business Manager, Virginia Journal of Science, c/o Department of Biology, V.P.I. and S.U., Blacksburg Va. 24061.

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## Abstracts of Papers

## Section of Agricultural Sciences

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

LIFE TABLES FOR THE FRIT FLY, *OSCINELLA FRIT*, IN REED CANARYGRASS IN VIRGINIA. W. A. Allen and R. L. Pienkowski. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Life tables of *Oscinella frit* (L.) were prepared for the spring and summer generations of 3 consecutive years. Mortality of the insect prior to entry into the host was regarded as the key factor that regulated population changes in reed canarygrass. Frequent rainfall during the egg-laying season was the most probable cause of mortality in this stage. The life table trend index was normally less than 100% suggesting that frit fly populations are not especially suited to reed canarygrass.

Paper previously published, 1975. Ann. Entomol. Soc. Am. 68:1001-7.

OCCURRENCE OF *FRUMENTA NUDINELLA* (LEPIDOPTERA: GELECHIIDAE) IN SOUTHWEST VIRGINIA, AND ITS POTENTIAL AS A BIOCONTROL AGENT OF HORSENETTLE. T. E. Bailey\* and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061.

Horsenettle (*Solanum carolinense* L.) is a persistent, native, prickly and perennial weed with a penetrating root system. It reproduces by creeping rhizomes and seeds, and can be propagated from root cuttings. Thus it is highly competitive and is a serious problem in pastures and cornfields of the southern and eastern states. A moth, *Frumenta nudinella* (Zeller), was discovered infesting horsenettle in southwest Virginia in the summer of 1975. The larvae attack at least two stages of the plant. They feed on the tips of young leaves before formation of fruits and pupate in characteristic leaf chambers in mid July. After the plant fruits in late July, the larvae are fruitborers; one larva is capable of destroying all the seeds within a berry. The larvae pupate inside the berries, emerging as adults between late August and late September. Infested berries are not easily detected until the formation of a fine membrane-covered, exit hole by the full grown larva just before pupation. Less than 2% of over 600 berries examined between August and September contained larvae of *F. nudinella*; each infested berry contained only one larva. Two hundred berries collected throughout October contained no insects. This moth is not known to attack other plant species. Its apparent host specificity, adequate coverage of the host life cycle, and capacity for seed destruction merit further investigation of its potential in limiting the spread of the weed.

COMPUTER ASSISTED LIVESTOCK INVENTORY CONTROL. K. P. Boward and H. W. Park\*. Dept. of Animal Science, VPI and SU, Blacksburg, Va. 24061.

Since April, 1975, the current livestock inventory of the VPI & SU Animal Science Department has been maintained using the Conversational Monitor System (CMS) running on an IBM 370 Model 158, located on the VPI campus. The active inventory consists of 2500-4000 head of beef cattle, sheep and swine carried in 16 teaching and research projects directed by 8 scientists at 5 locations in Virginia. Daily changes are reported to a central office on campus, and are posted to the respective project file twice weekly via an interactive terminal. Revised listings of the current inventory are made each quarter, with separate listings showing individual animals added or removed. Sample forms and schematic diagrams are presented. Details on computer programs used to manage and list livestock project files are available on request.

INSECTICIDAL CONTROL OF LICE ON SWINE. A. F. Buckman and J. E. Roberts, Sr., Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

Tests for the control of hog lice, *Haematopinus suis* (L.), were conducted from October to December of 1975 in Montgomery County, Virginia. The 212 animals used in gathering data were a mixture of Hampshire, Yorkshire, and crosses weighing from 250 to 450 pounds. Two locations were selected to provide sheltered and unsheltered conditions.

Three compounds were tested for the control of lice on swine: 1% Coral dust, SPOTON® (20% fenitrothion), and TIGUVON® (3% fenitrothion). These materials were applied at a rate of 1/2 ounce, 2 ml., and 1/2 ounce per 100 pounds of body weight respectively. Evaluation was based on total insect counts made weekly for approximately 20 animals in each treatment category. Resulting data from unsheltered animals showed an initial control of 100 percent for all three materials. This decreased to 21.5, 40.4, and 49.3 percent control respectively after a period of three weeks. Retreatment at this time gave better than 95 percent control for all materials through the remainder of the test.

In similar testing under sheltered conditions, SPOTON® gave 100 percent control throughout the test period.

BIOLOGY OF *Chionodes mediofuscella* (Clemens) (Lepidoptera: Gelechiidae) AND THE POTENTIAL OF SEED-FEEDING INSECTS AS BIOLOGICAL CONTROL AGENTS FOR ANNUAL WEEDS. F. L. Gave and R. L. Pienkowski. Dept. of Entomology, VPI & SU Blacksburg, Va. 24061.

Ragweeds are anemophilic composites of the genera *Ambrosia* and *Franseria*, and the most important aeroallergens in North America.

*Ambrosia trifida* L., giant ragweed, is a ruderal plant widely distributed in east and central North America. It is a tall, upright annual which reproduces only by seeds. Since it is not likely that a ruderal weed would be controlled by herbicides, it is a possible candidate for biological control.

The seed feeding moth, *Chionodes mediofuscella* (Clemens) is a potential agent for this control in areas where it does not now exist. We know of no evidence that this insect attacks plants outside the *Ambrosia*.

In early September, fruiting heads of giant ragweed were collected and placed in emergence chambers. Upon emergence, *C. mediofuscella* larvae were placed on an experimental diet. Larvae completed development on the diet, and adult eclosion occurred approximately two months later.

Because most annual weeds develop solely by seeds, they can be regulated by seed feeding insects. Some successful bio-control projects on annual weeds by seed feeding insects include: *Xanthium* sp., *Senecio jacobaea* L., *Tribulus terrestris* L., *Emex spinosa* (L.) Camp., and recently in Virginia, *Carduus nutans* L. (Supported in part by CSRS grant 216-15-42)

BIOLOGICAL TREATMENT AND RECYCLING OF SWINE WASTES ON AGRICULTURAL SOILS. E. R. Collins, Jr., E. T. Kornegay, and D. C. Martens. Depts. of Agricultural Engineering, Animal Science, and Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Anaerobic and mechanically-aerated treatment systems, with land recycling of effluent, have been studied since December, 1974. Designs allowing 200 ft.<sup>3</sup> of anaerobic lagoon volume per animal and an aeration rate of twice the estimated BOD<sub>5</sub> for the aerated lagoon, performed satisfactorily. Waste characteristics for both types of systems were established, including fertilization values for both types of effluent. Levels of Cu and Zn continued to rise in both lagoons during the study. Parallel rises in disposal plots were not detectable, but may be problematic with long-term land recycling. Irrigation of effluents on fescue-sod plots did not cause detectable deleterious effects on the soil-plant environment.

GROUNDWATER QUALITY AROUND THREE ANAEROBIC SWINE WASTE LAGOONS-3 YEAR SUMMARY. E. R. Collins, Jr., T. G. Ciravolo, D. C. Martens, D. L. Hallock, E. T. Kornegay, and H. R. Thomas. Depts. of Agricultural Engineering, Agronomy, and Animal Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Groundwater was monitored around three anaerobic swine waste lagoons located in the Coastal Plain region of Virginia. The lagoons were located at the Tidewater Research and Continuing Education Center (TRACEC), at the Virginia Swine Evaluation Center (VSEC), and on a private farm. The lagoons at VSEC and on the private farm were in operation for more than 8 years. The lagoon at TRACEC has been in operation since August of 1974. Wells were waterjetted to depths of 3, 4.6, and 15 m at 3-, 15-, and 30-m distances from the lagoons. Groundwater constituents determined were Cl, Cu, Mn, NH<sub>4</sub>, NO<sub>3</sub>, PO<sub>4</sub>, Zn, and fecal coliform bacteria. These analyses indicated no contamination in groundwater samples obtained beyond 3 m from lagoons located at TRACEC and VSEC. Groundwater samples from the lagoon at the private farm were consistently high in Cl, and either NH<sub>4</sub> or NO<sub>3</sub>.

SOIL SURVEY OF SELECTED BARRIER ISLANDS OF VIRGINIA. L. E. Cullipher, Soil Conservation Service, Prince George, Virginia 23875

A soil survey of approximately 33,000 acres of Barrier Islands and adjacent wetlands along the Eastern Shore of Virginia was made at the request of the Nature Conservancy. The soil survey was made by soil scientists of the Soil Conservation Service. This survey is part of the ecosystem and resources management study for the Barrier Islands. National Aeronautics and Space Administration (NASA) color infrared photography (CIR) and natural vegetation was highly useful in delineating soil mapping units. The area concerned is an extremely fragile, highly dynamic ecosystem very valuable for wildlife habitat and spawning and nursery grounds for finfish and shellfish. The purpose of the study was to obtain an inventory of the soil resources so that the Nature Conservancy can develop a management program for protection, and possible use, of the natural system.

MODELING THE IMPACT OF THE SOUTHERN PINE BEETLE. R. F. Daniels, W. A. Leuschner, H. E. Burkhardt. Dept. of Forestry and Forest Products, VPI&SU, Blacksburg, Va. 24061.

Models describing insect-host relationships and allowing comparisons of control strategies provide useful guidelines for Southern Pine Beetle (*Dendroctonus frontalis*, Zimm.) (SPB) pest management decisions. Benefits of SPB control are the prevented damages to forest resources, including timber, recreation, aesthetics, soil, water, wildlife, and grazing. The Potential Benefits Analysis Program (PBAP) assesses the current year potential benefits of various levels of control. Two timber subroutines which model mortality and subsequent stand values are currently operative. Recreation and other potential benefits are being formulated. Projection models for SPB spots and forest stand dynamics were developed to evaluate management alternatives. The frontalis simulator (FRONSIM) projects numbers of SPB spots assuming continued historical control levels. FRONSIM allows mortality benefit estimation for future years. Stand development in managed loblolly pine is projected by PTAEADA, a model based on the growth of individual trees. PTAEADA will also be used in testing probabilities of SPB attack and spread for different management strategies and as a sampling tool for regional impact estimates. Other investigations include a model to analyze the impact of the SPB on income and wealth distributions.

RECURRENT SELECTION FOR YIELD IN THE F<sub>2</sub> OF A MAIZE SINGLE CROSS. C. F. Genter. Department of Agronomy, VPI & SU, Blacksburg, Va. 24061.

A population derived from crosses of F<sub>2</sub> plants of a maize single cross hybrid was advanced through four cycles of recurrent selection for yield. The most productive crosses of each cycle were intercrossed to produce the next cycle. Any shifts in gene frequency from that of the F<sub>1</sub> would tend to be toward homozygosity. Tests were conducted of 208 F<sub>2</sub>-plant, 190 C<sub>1</sub> (cycle 1), 105 C<sub>2</sub>, 62 C<sub>3</sub>, and 101 C<sub>4</sub> crosses. Yield increases were from 59.9 to 80.4% of F<sub>1</sub> for the population mean, from 31.6 to 58.3% of F<sub>1</sub> for the minimum progeny yield, and from 91.6 to 99.8% of F<sub>1</sub> for the maximum progeny yield. In both C<sub>3</sub> and C<sub>4</sub> the lowest progeny yield exceeded that of the F<sub>2</sub> check. The overall frequency of desirable genes must have increased, but some deleterious genes must have been maintained in sufficient frequency to suppress the maximum potential among the genotypes. Assuming complete dominance, the cumulative depressive effect of homozygous deleterious genes in the F<sub>2</sub> was estimated to be at least 26.7%. A negative correlation was found between date of F<sub>2</sub>-plant pollination and yield of their progeny, suggesting that the earlier segregates carried a lighter load of deleterious genes. Selection of earlier segregates may be an additional useful breeding tool.

RESPONSE OF PEANUTS TO LANDPLASTER 1964-1975. D. L. Hallock, Tidewater Research and Continuing Education Center, Va. Polytechnic Inst. and State Univ., Holland Station, Suffolk, Va. 23437.

Twelve years of peanut response to landplaster (LP) is summarized. Landplaster at rates of 0 or 600 to 800 lb./A (normal) were applied on 27 field sites and rates in excess of 1000 lb./A on 26 field sites, (mostly different than the previous 27 sites), during this period. Soil textures included loamy fine sands and fine sandy loams.

Gross crop values (GCV) where the lower LP rates were applied averaged \$40/A higher than where no LP was applied. Responses in GCV to normal LP rates on the Sassafras, Woodstock, Dragston-Bertie, and Norfolk soils were \$48/A, \$29/A, \$61/A and \$28/A, respectively.

Application of LP in excess of 1000 lb./A increased average GCV by \$77/A over the no-LP reference plots. Responses in GCV to LP on the Sassafras, Woodstock, Dragston-Bertie, and Norfolk soils were \$62/A, \$69/A, \$112/A, and \$43/A, respectively.

The increased GCV from application of LP resulted primarily from increased yields. Seed size, which is an economic factor, also was increased slightly by LP.

Variations in soil Ca levels were not closely related to GCV response variability. However, this relationship was closest (direct) for the Dragston-Bertie group which averaged highest in dilute double-extractable Ca levels.

EVALUATION OF SOYBEAN HULLS FOR GROWING SWINE. M. A. Harowitz\* and E. T. Kornegay, Dept. of Animal Science, VPI and SU, Blacksburg, VA 24061.

Two feeding trials using 140 crossbred pigs (60 pigs in trial 1-avg. initial wt. was 35.4 lb; 80 pigs in trial 2-avg. initial wt. was 40.5 lb) were conducted to evaluate the use of soybean hulls in growing rations. Soybean hulls were used in a 16% protein corn-dehulled soybean ration at 0, 2, 4 and 8% in trial 1, and 0, 2, 4 and 12% in trial 2. Length of trial was 4 weeks in trial 1 and 5 weeks in trial 2. Gross energy (kcal/kg), crude protein (%), crude fiber (%), ash (%), and ether extract (%) for soybean hulls were: 3935, 4029; 11.2, 13.7; 41.4, 45.0; 4.3, 4.5; 2.4, 2.9, respectively, for trials 1 and 2. There were no differences in average daily gains (ADG), average daily feed intakes (ADFI) and feed/gain ratios (F/G) among the various levels of added soybean hulls in both trials. In trial 1, means were: 1.32, 1.39, 1.39 and 1.36 for ADG (lb); 3.25, 3.44, 3.38 and 3.44 for ADFI (lb); 2.47, 2.47, 2.44 and 2.53 for F/G, respectively, for 0, 2, 4 and 8% added soybean hulls. In trial 2, means were: 1.55, 1.55, 1.57 and 1.54 for ADG; 3.88, 4.00, 3.99 and 4.07 for ADFI; 2.50, 2.59, 2.53 and 2.64 for F/G, respectively, for 0, 3, 6 and 12% added soybean hulls. It can thus be concluded that soybean hulls of the type fed in these trials can be used in swine rations to supply energy and protein at levels up to about 12% without reducing feedlot performance.

EVALUATION OF TWO DIETARY ENERGY LEVELS FOR PIGS WEANED AT SEVEN DAYS OF AGE. S. N. Hays, J. D. Blah\* and E. T. Kornegay, Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061.

Three feeding trials using 96 pigs weaned at 7 days of age (average initial body weight of 2.8 kg) were fed soy-whey (SW) and dried skim milk (DSM) diets with 0, 5 and 10% added corn oil (CO). The basal diets contained 10% fat. The diets were hand-fed twice daily so that there was diet in the troughs at all times, but at a level so that the diet did not accumulate. Pigs were housed in triple deck cages in an environmentally controlled building and fed to a final weight of 5.6 kg. Feed consumption and body weight were determined weekly. In trial 1 where DSM diets were fed there was a trend (P<.10) for average daily gain (ADG) and average daily diet intake (ADDI) to be improved when 5% CO was added. Feed per gain ratios (F/G) were not different. The addition of 10% CO seemed to depress ADGI. In trial 2 and 3 SW diets were fed. In trial 2 ADG (P<.10) and ADDI (P<.05) were increased during the fifth week when 5% CO was added. F/G was not affected. In trial 3, no improvement in any parameters occurred when 5% CO was added to the diets. These results suggest that diets for pigs at 7 days of age may contain from 10 to 15% fat.

ANTIBODY AND IMMUNOGLOBULIN FORMATION IN ARTIFICIALLY RAISED PIGS. S. N. Hays and E. T. Kornegay, Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061.

Fifty-five pigs from 8 sows were used to compare the development of immunity in sow-reared pigs as compared to artificially-reared 12-hr weaned pigs. Pigs at birth were removed from the sow until farrowing was complete. Then all pigs were allowed to nurse 12 hr to insure equal immunoglobulin intake. At that time one half of the pigs (M) were weaned to a mechanical sow. The remainder of the pigs (S) served as littermate controls. Body weights were recorded and blood samples via vena cava were taken at 12 hr and every 5 days thereafter for 30 days. All pigs were weaned at 20 days and placed in flat deck cages. Antibody titers at 5 (T1) and 10 (T2) days after an intraperitoneal injection of a 10% suspension of sheep red cells (SRBC) on day 20 were lower (P<.05) for M pigs as compared to S pigs at T1 and T2. Injection of SRBC at 25 days yielded lower titers for M pigs as compared to S pigs only at T2. Gamma globulin levels and final body weights were not different between M and S pigs. Artificially-reared 12-hr weaned pigs had a decreased ability to produce antibodies even though growth and gamma globulin levels were not different from littermate controls.

HEATING SWINE HOUSING WITH SOLAR ENERGY. G. L. Hill\*, D. H. Vaughan\*, E. S. Bell\*, and R. A. Hughes\*. Dept. of Agricultural Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Confinement swine production in the U.S. depends on energy, requiring  $2.3 \times 10^{12}$  BTU annually. The energy, nearly all derived from electricity or L.G.P. is used mostly in the farrowing and nursery phases of production. Heating systems using alternate energy sources such as solar, along with effective energy conservation, is required to minimize the reliance on fossil fuels.

A project at VPI & SU is investigating the utilization of solar energy for heating a swine nursery building. The research involves collecting solar energy as heat, storing it in a water impoundment, reducing heat loss from the storage back to the environment, and extracting the heat from the water by a heat pump for use in temperature control of the nursery building. Commercially available flat-plate collectors are being evaluated with regard to collector efficiency, life, and maintenance costs. An existing waste lagoon is used for heat storage and several surface coverings are being evaluated for reducing heat loss. Water is circulated, in a closed system with heat exchangers, from the lagoon through the collectors and over the exterior coils of the water-to-air heat pump. Increasing liquid temperature increases the heat pump coefficient-of-performance resulting in energy savings and elimination of direct-fired fossil fuel heaters. (Research supported by USDA-ARS)

FIELD TESTING INSECTICIDES ON PEANUTS FOR THE CONTROL OF THE POTATO LEAFHOPPER, EMPOASCA FABAE (HARRIS), IN VIRGINIA. J. W. Jenkins and J. C. Smith, Tidewater Research and Continuing Education Center, VPI & SU, Suffolk, Va. 23437.

New and standard pesticides were evaluated for efficacy in controlling populations of the potato leafhopper, Empoasca fabae (Harris) on peanuts. Population levels were the criteria for rating pesticides. Infestations were sampled approximately every seven days using a 12 inch sweep net. Grade, yield, and value per acre were determined for each treatment. Many pesticides demonstrated superior persistence and significantly better control of the leafhopper. The coefficient of determination showed a low correlation between infestations and yields. The results suggest that population levels in all treatments did not reach the economic threshold.

CORTISOL BINDING CAPACITIES AND ASSOCIATION CONSTANTS OF PREGNANT SOWS UNDER APPLIED STRESS. H. G. Kattesh\*, E. T. Kornegay, H. R. Thomas and F. C. Goadzhuks\*, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061.

Twelve Yorkshire sows (Y), and 12 crossbred sows (X), 22 to 39 days postbreeding, were used to determine the effect of applied stress (heat and crowding) on corticoid levels, cortisol binding capacity to Corticosteroid Binding Globulin (CBG), the affinity of cortisol to bind to CBG (Ka), the number of pigs born alive, and pig survival rate at 7 days. The stressed sows (T), in groups of 6, were housed in totally slatted floor pens (2.0 x 2.7 m) in an enclosed ventilated building at 31 C. Stress began late in the first trimester of pregnancy lasted for 50 days. Plasma corticoids were measured by CFB assay. Cortisol binding capacity and Ka were determined by radioassay and modified Scatchard plot analyses. Three of 6 Y sows and 5 of 6 X sows under stress farrowed, and all controls farrowed. T1 corticoid concentrations and cortisol binding capacities (25.4±1.9 ng/ml,  $\bar{X} \pm SE$ , n = 64; 15.2±1.7  $\mu$ g/100 ml, n = 32) were lower (P < .01) than T2 (40.1±2.1 ng/ml, n = 96; 18.1±1.7  $\mu$ g/100 ml, n = 48). No treatment differences were seen for Ka and number of pigs born alive. A significant (P < .01) treatment and breed X treatment interaction was detected for number of pigs alive at 7 days (T1 < T2; X1 < Y1). These results suggest that heat and crowding stress during mid-pregnancy altered corticoids and cortisol binding capacity and may be related to survival of the offspring.

THE CULICOIDES BITING GNATS (DIPTERA: CERATOPOGONIDAE) OF THE DISMAL SWAMP IN VIRGINIA AND NORTH CAROLINA. W. L. Knausenberger, and E. C. Turner, Jr. Dept. of Entomology, V.P.I. & S.U., Blacksburg, Va. 24061.

As part of a continuing study of the immature Ceratopogonidae of eastern North America, 64 paired substrate samples were taken throughout the greater Dismal Swamp over a one-year period. Site selection was aimed at locating the types of larval habitat preferred by the ceratopogonid species which occur in the Swamp. Adults were obtained by UV light trap, tent trap, sweep net, and by aspirating *Culicoides* which landed on humans.

The evidence of this study to date indicates that the *Culicoides* population in the Swamp is low to moderate, contrary to a popular notion and casual remarks in scientific reports on other fauna, which reported "biting gnats" as being very bothersome. Only 26 (ca. 40%) of the larval substrate sites yielded *Culicoides*, and of these only 4 (ca. 6% of the total) could be considered productive (more than 20 individuals). The number of adult biting midges collected *in situ* by all methods during all collection periods was consistently low.

To the present, only five *Culicoides* species have been encountered: *arboricola*, *debilis*, *furcata*, *haematopis*, and *stellifer*. An analysis of their larval distribution as related to physical, chemical and biotic factors is presented.

AMINO ACIDS AND OTHER NITROGEN COMPONENTS OF SWINE FECAL WASTE AND UTILIZATION OF THESE NUTRIENTS BY SWINE. E. T. Kornegay, H. R. Holland\*, K. E. Webb, Jr., K. F. Boward and J. D. Hedges. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061.

It was reported previously that the digestibility of dry matter, energy, ash, crude fiber, ether extract, NFE, calcium, phosphorus, potassium, copper and zinc were reduced when fresh or dried swine feces were substituted for a basal corn-soybean meal ration, however, a significant portion of these nutrients was available to the gilts. This study was extended to characterize swine feces as to its composition of amino acids and other nitrogen components and to determine digestibilities and retention values for these nutrients when fed to swine. The fecal concentration of amino acids in general decreased as feces were substituted which was a reflection of increased fecal output and lower digestibility. Feces from the gilts fed feces substituted rations were significantly lower in crude and true protein. Digestion of crude and true protein was reduced as feces were substituted for the basal ration with digestion coefficients of (X): 60.1 and 51.4, respectively, for feces calculated by difference. With the exception of serine, glycine and cysteine in which digestion coefficients were lower, the digestibilities of the other amino acids ranged from 51.2 to 65.1 percent.

THE EFFECTS OF OZONE (O<sub>3</sub>) ON SOYBEANS GROWN AT VARIOUS LEVELS OF PHOSPHORUS. Mark J. King\* and Laurence D. Moore. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Four closely related breeding lines (600, 602, 595 and 582) of soybeans were grown in a charcoal filtered greenhouse. These lines were chosen because 582 and 595 developed symptoms similar to those caused by oxidant fumigation under field conditions. They were supplied with Hoagland's solution modified to provide 15, 30, and 60 ppm phosphorus. 32 day-old plants were fumigated with 50 ppm O<sub>3</sub> for 6 hrs. Foliar symptoms on the primary and first trifoliolate leaves were recorded over a 7 day post-fumigation period. O<sub>3</sub> injury was observed as upper surface flecking and was uniformly present on plants of all four lines. There was no correlation between symptom expression due to O<sub>3</sub> fumigation and the amount of phosphorus supplied. Incidence of marginal necrosis increased depending on the time of year and was independent of the phosphorus or O<sub>3</sub> treatment. Veinal reddening was extensive on 595 and 582 and increased in incidence from winter to spring. Since the incidence of veinal reddening and marginal necrosis varied with respect to season some other environmental factor may cause the oxidant like symptoms under field conditions. Recent research has implicated ultraviolet light. There might be interaction between ultraviolet light and O<sub>3</sub> in producing foliar symptoms.

EFFECT OF NUMBER OF PIGS PER CAGE AND DIETARY CITRIC ACID ON PERFORMANCE OF PIGS WEANED AT SEVEN DAYS OF AGE. E. T. Kornegay, S. N. Haye and J. D. Blaha\*, Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061.

Performance of pigs weaned at 7 days of age and housed one, two and three per cage in triple deck pig batteries was measured in two trials (1-21 days and 2-24 days) using 48 crossbred pigs avg. 2.6 kg body weight. In a third 21-day trial using 32 pigs weaned at 7 days of age (avg. 2.4 kg of body weight), two milk base diets, a commercial sow milk replacer and an experimental dried skimmed milk diet (also fed in trials 1 and 2), were fed with and without 1% citric acid. Room temperature was 32° C initially. The diets were hand-fed twice daily so that there was diet in the trough at all times, but at a level so that the diet did not accumulate. Performance of pigs in trials 1 and 2 was statistically different. Avg. daily gains (g), avg. daily diet intakes (g) and diet/gain (avg. for trials 1 and 2) for one, two and three pigs per cage, respectively, were: 220, 204 and 189; 372, 313 and 323; 1.69, 1.54 and 1.71. There were no beneficial effects of adding 1% citric acid to the commercial or experimental diets and there was no difference in the performance of pigs fed the two diets. Avg. daily gains (g), avg. daily diet intakes (g) and diet/gain of the commercial diet with and without citric acid and for the experimental diets with and without citric acid, respectively, were: 177 and 163, 173 and 181; 286 and 266, 285 and 283; 1.62 and 1.63, 1.65 and 1.57.

BIOLOGICAL STUDIES OF *PHILONTHUS COGNATUS* STEPH. (COLEOPTERA: STAPHYLINIDAE) AN INDIGENOUS PREDATOR OF THE ALFALFA WEEVIL. F. W. Larkins and R. L. Pienkowski, Dept. of Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061.

*Philonthus cognatus* Steph. occurs in alfalfa fields of at least three southwestern Virginia counties. Adults are mostly black, extremely active insects with body lengths of 11 to 16 mm and head widths ca 1.5 mm. Adults aggregate under alfalfa debris where soil moisture is high. Disturbed, adults assume a defensive posture exposing scent glands (located on the caudal end of the abdomen) which secrete a pungent odor.

Females lay up to three eggs per day on soil surface and in crevices. Eggs are distinctly reticulated, white, and elliptical (ca 1 x 2 mm). Eggs hatch in ca 7 days at ca 22°C.

*P. cognatus* has three campodeiform larval instars. First and second larval stadia are 3 to 4 days long. Pupation occurs about 8 days after the last larval molt. Third larval instars feed for 4 or 5 days before forming a pupal chamber ca 2 cm below the soil surface. Pupae are oblong, ca 3 mm long and 2.3 mm wide. Adults emerge ca 11 days after pupation and remain at least 1 to 2 days in the pupal chamber.

Adults and larvae prey upon alfalfa weevil larvae. Adults in laboratory tests consume ca 3.1, 3.3, and 4.7 fourth instar weevil larvae using 5, 10, and 15 larvae per staphylinid respectively. Adults and larvae also prey upon calliphorid larvae. (Aided by CSRS grant 516-15-41)

**IMPORTANT VARIABLES RELATED TO TEST PERFORMANCE OF BULLS.**  
T. J. Marlowe and J. W. Osborne\*, Dept. of Animal Science,  
Virginia Polytechnic Institute and State University,  
Blacksburg, Virginia 24061

Date on 846 Angus (A), 66 Charolais (C), 98 Hereford (HH) and 370 Polled Hereford (PH) bulls tested during 1969-75 at 3 locations were analyzed to deter. imp. variables on performance. Traits were test ADG, 365-d wt., F wt., hip ht. (hh), wither ht. (wh), frame score (FS) and grade (G). Var. were yr and loc. of test; dam age; creep; beginning age (b-age), wt., cond. score (CS), head score (HS), masculinity (MS); and polled cond. in PH. Breeds analyzed separately to deter. perf. and var. affecting perf. for each breed. Loc. effect was sig. only for HH and PH. Yr effect generally sig. for all traits in all breeds. Cow age not sig. for traits other than 365-d wt. Creep had a sig. + effect on all growth traits except FS in A, but not in C, HH, or PH. PH bulls superior to HH in all traits. Both b-age and wt. sig. for all traits measured. Older bulls had better test gains and heavier F wts. but lower 365-d wts., WDA and FS. B-wt. most imp. var. Magnitude similar for all breeds. Neither HS, CS, or MS at start of test was sig. on growth except for C bulls where MS was - related and HS + related to growth. There was a sig. negative correlation between condition and frame score.

**EFFECT OF HAND DEFOLIATION ON YIELD AND QUALITY OF SOYBEANS.**  
T.J. McAvoy\* and J.C. Smith. Dept. of Entomol., V.P.I. & S.U., Blacksburg, Va. 24061, and Tidewater Res. and Cont. Ed. Center, V.P.I. & S.U., Suffolk, Va. 23437.

Two soybean varieties, York and Shore planted on June 5 and June 19, 1975, were hand defoliated at 33, 67 and 100% levels, to simulate insect defoliation. Defoliations were made at 5 growth stages: V-I, 2 trifoliolate present; V-III, 6 trifoliolate present; R-V, mid-bloom; R-VII, bean filling; and R-IX, beans fully developed. Defoliations had no effect on purple stain, a fungus disease on the seed coat. In the earlier planting, 67 and 100% defoliations at growth stages R-V and R-VII, helped reduce the amount of lodging by reducing the amount of resistance to wind and rain. Lodging was unaffected by defoliation in the second planting. Height to the first pods was increased by defoliations in growth stage R-VII. The greatest reduction in yield and seed size resulted from defoliations at growth stage R-VII. Defoliations of 100% caused an average yield loss between the two varieties of 90 and 92% for the first and second planting dates, respectively. Yield reductions were generally followed by a reduction in seed size and seed quality. Both varieties of the second planting suffered a greater loss in yield and seed size than the first planting when comparing equivalent treatments. Yield losses due to defoliation given in descending order were as follows: Mid-bloom stage (R-V), bean filling (R-VII), fully developed bean stage (R-IX), 6 trifoliolate stage (V-III) and 2 trifoliolate stage (V-I).

**ADDITIONAL HOST PLANTS OF *HETERODERA CAROTAE*, *H. AENAE*, AND *H. HUMULI*.** L.I. Miller, Dept. of Plant Pathol. and Physiol., Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061

The following plants were tested in 1974 in the greenhouse at the Rothamsted Experimental Station in England as possible hosts of *Heterodera carotae*, *H. aenae*, and *H. humuli*: *Humulus lupulus* ('Fuggle' hop), *Daucus carota* ('Valery' carrot), *Avenae sativa* ('Milford' oat), *Rumex crispus* (yellow dock), *Vicia faba* ('Banks' broadbean), *Vicia sativa* (spring vetch), *Pisum sativum* ('Wonder' garden pea), *Glycine max* ('Lee' soybean), *Solanum nigrum* (N.Y. isolate of black nightshade), *Physalis francheti* ('Dobie' Chinese lantern), and *Brassica oleracea* var. *capitata* ('Greyhound' cabbage). Inoculum of forty cysts with viable eggs and larvae of an Isle of Ely isolate of *H. carotae*, the Pentland Prime isolate of *H. aenae*, or a Kent County isolate of *H. humuli* was added to each 3.5-inch pot of Callawaert's cyst-free soil mixture. The cysts were enclosed in a Terylene cloth bag and placed in the center of each pot just prior to transplanting the hop cutting or 3-week-old seedlings of other plants. After 7 weeks, roots were examined for the presence of fifth stage females. *H. carotae* reproduced on the carrot check and a few females were formed on roots of yellow dock and spring vetch. *H. aenae* reproduced on the oat check and a few females were formed on hop, spring vetch, black nightshade, and cabbage and a medium number (greater than 10 females/pot) on soybean. *H. humuli* reproduced on the hop check and a few females were formed on carrot, oat, and black nightshade.

**INTERSPECIFIC CROSS OF *HETERODERA SCHACHTII* AND *H. GLYCINES*.** L. I. Miller, Dept. of Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061

Experiments were initiated in 1974 at the Rothamsted Experimental Station in England to test the validity of the reports by Porter and Fox in 1965 that amphimictic *Heterodera schachtii* and *H. glycines* would cross and form interspecific hybrids. One larva of the Shepherd isolate of *H. schachtii* and one larva of an inbred culture of either the Miss. 1 or N.C. 1 isolate of *H. glycines* were added to the bottom of a hole (0.15-inch diameter, 0.5-inch deep) adjacent (ca 0.2-inch) to a single 2.5-week-old Pearson A-1 tomato seedling planted in a 2.0-inch pot containing Callawaert's cyst-free soil mixture. The attempted cross of *H. schachtii* with the Miss. 1 isolate of *H. glycines* was repeated 69 times and the attempted cross of *H. schachtii* with the N.C. 1 isolate of *H. glycines* 49 times. Roots were examined after eleven weeks for the presence of fifth-stage females. One gravid female with *F<sub>1</sub>* larvae was obtained in the cross of *H. schachtii* with the Miss. 1 culture of *H. glycines* and three gravid females in the cross with the N.C. 1 culture of *H. glycines*. It is concluded that the hybrids formed in the two crosses were fertile since gravid females were formed on tomato following inoculation with *F<sub>1</sub>* larvae.

**IMPORTANT VARIABLES RELATED TO SALE PRICE OF PERFORMANCE TESTED BULLS.** John W. Osborne\* and Thomas J. Marlowe, Department of Animal Science, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061

Date included 597 Angus (A), 48 Charolais (C), 75 Herefords (H) and 293 polled Herefords (PH) sold at Culpeper, Dublin and Red House during 1969-1975. Average sale price was \$959, \$832, \$614, and \$928 for A, C, H and PH, respectively. Sale price varied greatly among years with an overall high in 1974 and low in 1970. Traits considered important differed for buyers of different breeds, but location of sale was not important. Buyers of all breeds considered yearling weight (365 days) of major importance, worth \$589 in A, \$134 in C and \$578 in H and PH for each 100 pounds above the average. Other significant variables included grade, age (except for C), frame score and polled or polled condition in Hereford (polled bulls averaged about \$60 more), condition in A (fatter bulls sold for less) and gain on test for C only (\$22.27 per 1/10 pound above average). Non-significant variables included location, sale order, 205-day weight, muscling score, and frame score, except in Herefords where it was highly correlated with grade.

**BIOLOGICAL STUDIES OF *OIDAEMATOPHORUS MONODACTYLUS* (L.), A PLUME MOTH COMMONLY INFESTING BINDEWEEDS IN VIRGINIA.** M. Parrella and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, Va. 24061.

In southwestern Virginia, the plume moth, *Oidaematophorus monodactylus* (L.) becomes active around the last week in May. This coincides with the spring growth of the bindweeds (*Convolvulus arvensis* L. and *C. sepium* L.). It undergoes 2 or more generations per year. Females mated more than once when maintained at 25°C in the laboratory. After a preoviposition period of 2 to 3 days, each laid an average of 145 eggs. The eggs were laid singly on the underside of leaves, on tender, young shoots, and on new buds. The duration of the egg stage was 3.5 days; rate of hatch was 61%. First instars fed gregariously in the vicinity of where the eggs were laid. Dispersal occurred as the larvae developed. Average leaf area consumed per larva was 12 cm<sup>2</sup>, 80% of which was consumed by the last instar. There were 4 instars with durations of 2.8, 3.0, 3.3, and 6.6 days. Pupation occurred on the underside of the leaves. The pupal stage averaged 7.6 days. Mean developmental period from egg to adult was 26.8 days. The average longevity of the adults was 28.7 and 26.7 days for the female and male respectively. Feeding tests conducted in the greenhouse revealed that the plume moth could effectively destroy a bindweed plant.

PHOSPHORUS IN NATURAL SOIL SYSTEMS AS INFLUENCED BY DOMESTIC WASTE DISPOSAL. R. B. Reneau, Jr. Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Phosphorus (P) accumulations were determined for selected soil horizons from two Coastal Plain soils utilized for domestic waste disposal. The soils studied were a Plinthic Paleudult and a Typic Ochraqult. The influence of domestic waste disposal on P movement through these soils was determined by analyses of samples collected as a function of distance from the disposal area. Soil P fractionation of these samples indicated that P from domestic wastes was present primarily as Al-P and Fe-P with increased organic P present adjacent to the disposal area. In the Plinthic Paleudult P accumulated in the argillic horizon above the less permeable plinthic material. Total P concentrations of 1,317  $\mu\text{g/g}$  were present at 0.15 m distance from the disposal area. In the Typic Ochraqult, P accumulated in the argillic horizons in excess of 400  $\mu\text{g/g}$  at 1.5 m from the drainfield. In both soils the zone of influence on soil P accumulation was less than 5.0 m. P adsorption by the Typic Ochraqult could be described by Langmuir adsorption theory. These P adsorption isotherms reflected the influence of domestic waste disposal on soil P status.

CONTROL OF SOIL INSECTS AFFECTING CORN. James E. Roberts, Sr. and Daniel E. Brann, Dept. of Entomology and Dept. of Agronomy, respectively, VPI & SU, Blacksburg, Va. 24061

Several insecticides are approved by E.P.A. and recommended by V.P.I. & S.U. for the control of insects affecting corn in Virginia. These insecticides are applied in front of the press wheel at planting time. Most of these insecticides were tested in small replicated plots at two locations in the coastal plains of Virginia in 1975. Some of these same insecticides were tested in large non-replicated plots at several locations in the state. For the most part, treated plots did not result in increases in yield when compared with untreated plots.

A RAPID BIONOMONITORING PROCEDURE APPLIED TO AGRICULTURAL CHEMICALS IN THE AQUATIC ENVIRONMENT. D. E. Simonet, W. I. Knausenberger, and L. H. Townsend, Jr., Department of Entomology, VPI & SU, Blacksburg, Va. 24061

A new type of toxicity test has been developed as a bio-assay tool in the assessment of aquatic pollution. It involves measuring inhibition of the negative phototactic response of first instar *Aedes aegypti* larvae (Diptera: Culicidae) which had been exposed, immediately upon hatching, to a number of toxicants. Our studies on point source discharges of heavy metals indicated that this technique is sensitive and can be rapidly administered. In addition, it avoids the difficulty of subjectively determining mortality at threshold levels, as often must be done in conventional toxicological studies with aquatic organisms.

The present study explores the possibility of using the mosquito inhibition test to detect toxic levels of pesticides which commonly enter the aquatic system from diffuse sources. The test included several insecticides and herbicides which appear in non-point agricultural runoff. The technique is effective in detecting sublethal quantities of many of these substances under laboratory conditions. Photomigration provides a rapid and efficient means of objectively determining response of larvae exposed to sublethal concentrations of insecticides.

PROBLEMS ASSOCIATED WITH SAMPLING FOR THE POTATO LEAF-HOPPER, *EMPOASCA FABAE* (HARRIS), IN ALFALFA. D. E. Simonet and R. L. Plonkowski, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The potato leafhopper, *Empoasca fabae* (Harris), overwinters only in the Gulf Coast area of Louisiana and Mississippi and northern Florida. Each spring it migrates north arriving in Virginia in late May or early June. The leafhopper causes its greatest damage to alfalfa in late June or early July when it reaches peak population levels.

A major problem in the study of the population dynamics of any animal is obtaining an accurate sample of the field population. A proposed sampling technique for leafhopper eggs, which are laid inside the fibrous stems and leaf petioles, has been to clear stems in a lactophenol-acid fuchsin solution. Laboratory evaluation has also been conducted on methods of extracting nymphs from foliage samples. Several sampling methods have been compared in the field for determination of adult populations. These include 2 sweep net methods, 2 D-Vac sampling methods, and a drop net technique.

Problems encountered using these sampling techniques have been caused by the aggregated distribution of the leafhopper, and its low population densities at certain times of the year. Several data transformations have been evaluated in an attempt to normalize the data to allow parametric statistical analysis.

FERTILIZATION OF WHITE OAK SEEDLINGS IN THE VIRGINIA PIEDMONT. D. M. Smith\*, H. N. Chappell\*, and R. E. Adams. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The survival of planted oak seedlings is characteristically good, however, growth is often very poor with dieback and subsequent sprouting prevalent. The effects of fertilization with two levels of diammonium phosphate on growth and foliar nitrogen and phosphorus concentrations of 1-0 *Quercus alba* L. field planted seedlings were evaluated one year after planting and fertilization. Soil P tests were made by three methods: dilute acid extractable P, acid fluoride extractable P, and total P by perchloric acid digestion.

Confounding factors, including site variation, seedling stress from planting, and an equilibration period of only one growing season, suggest that treatment effects will require more than one growing season to be conclusive. Site factors were the most common source of variation for growth and soil P measurements. Dilute acid extractable P was significantly correlated with height growth and may be a good diagnostic technique for determining possible phosphorus deficiencies in white oak seedlings.

(Supported by Reynolds Homestead Research Foundation and McIntire-Stennis Grant 636235-0)

TWOSPOTTED SPIDER MITE, *TETRANYCHUS URTICAE* KOCH, CONTROL ON PEANUTS. J.C. Smith and R.W. Mofing, Tidewater Res. and Cont. Ed. Ctr., V.P.I. & S.U., Suffolk, Va. 23437.

Various regimes of granular, systemic-insecticide applications were compared with preventative applications of foliar sprays for spider mite control.

In 1974, in-furrow and band treatments of aldicarb gave superior spider mite control and were equal to preventative spray treatments of carbofuran and monocrotophos. The spray treatment of carbaryl + molasses (Sevinol) became severely infested. Carbofuran (band-incorporated) and carbaryl (80 S formulation) had infestations greater than the untreated control. The disulfoton treatment (in-furrow) was equal to the control.

In 1975, superior treatments were aldicarb as a split treatment (in-furrow + band @ pegging), monocrotophos spray and dicofol spray. In-furrow applications of aldicarb were effective and equivalent to aldicarb band treatments at higher rates. In-furrow applications of aldicarb which received superimposed spray applications of carbaryl had moderate populations of spider mites. Severe infestations occurred on disulfoton (in-furrow) and carbofuran (band) and were equivalent to the untreated control. The most severe infestations occurred on carbaryl (flowable formulation) and DBCP (soil injected) plots.

Yield and value/acre figures reflected the severity of spider mite injury in both years' experiments.

**DETERMINATION OF BPW CONCENTRATION USING SINGLE RADIAL IMMUNODIFFUSION.** Michael T. Spitzer, Sue A. Tolin and Laurence D. Moore. Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, Va. 24061.

Single radial immuno-diffusion was investigated as a possible method for quantifying bean pod mottle virus (BPW) from crude or partially purified plant extracts. Diffusion of rabbit antiserum specific to BPW were combined with 3 parts of 1% ionagar No. 2 containing 0.0125% sodium azide. A 1mm thick, 7 x 8 cm layer of the antiserum-containing agar was subsequently formed between two photographic glass plates (8.3 x 10.2 cm) separated by a brass frame. Wells were formed in the agar layer with a 4mm cork borer and suction. Using a microliter syringe, 4 µl of antigen was added to each well. The plates were allowed to incubate in a moist chamber for 24 hrs, after which the area of the resulting precipitin rings was calculated. The contrast of the rings could be enhanced by rinsing with 5% acetic acid. For permanent storage, the plates could be stained with Amido Black. A final antiserum dilution of  $1:256$  ( $1:256$ ) was determined to be optimum for development of the precipitin rings. The minimum concentration of purified BPW that was detected was 4 µg/ml. The area of the precipitin ring was found to be directly proportional to the antigen dilution between 10 and 250 µg/ml. Concentration of BPW in infected soybean tissue was generally less than 50 µg/ml.

**EFFECTS OF CONFINEMENT AND DIRT LOT HOUSING ON THE SEXUAL ACTIVITIES OF BOARS.** H.R. Thomas, E.T. Kornegay and T.N. Meacham. Tidewater Research and Continuing Education Center, Suffolk, Va. 23437 and Department of Animal Science, VPI & SU, Blacksburg, Va. 24061.

Two trials using forty boars per trial were conducted. The boars were approximately 12 weeks old when the studies were initiated. Trial I was conducted using two replicates of purebred Yorkshires and two replicates of Duroc, Hampshire Yorkshire crossbreds. In trial II all boars were purebred Yorkshires. Boars were randomly assigned to either dirt lots or partially slatted concrete floor pens. Assignments were based on age, weight and breed. A standard corn, soybean meal diet, formulated to contain 16% protein, was used. Boars were self-fed to 200 pounds body weight and hand-fed thereafter. A constant supply of cycling gilts was available and boars were exposed to gilts in heat at weekly intervals. Boars were individually scored to determine age of puberty, using the following code: 1 = no interest, 2 = interest, 3 = mounting without penetration, 4 = mounting with penetration and 5 = mating. The difference in number of boars reaching sexual maturity was not significant due to treatments. In both trials, boars reared in dirt lots reached puberty earlier than boars reared in concrete floor pens. An analysis of these data from trial I revealed that these differences were highly significant.

**EVALUATION OF AIR-CONDITIONED SWINE HOUSING DURING THE SUMMER BREEDING SEASON.** H.R. Thomas, E.T. Kornegay and T.N. Meacham. Tidewater Research and Continuing Education Center, Suffolk, Va. 23437 and Department of Animal Science, VPI & SU, Blacksburg, Va. 24061.

Forty-eight Hampshire, Duroc, Yorkshire crossbred sows were used in this study. Prior to going on this study all sows had suckled and weaned a litter of pigs. The sows were randomly assigned to two treatments, namely, air-conditioned housing and housing where temperature varied with outside weather conditions. Houses were partially or fully slatted concrete floors. Temperature in the air-condition house was maintained at approximately 70°F. Average maximum outside temperatures for the months of July, August, September and October were 86.2, 90.2, 80.8 and 74.0°F respectively. Twenty-four sows were bred under each housing situation. Twenty-three sows under each housing situation conceived and farrowed litters. Average litter size, birth weight and still births were 11.87, 2.98, .42 and 11.09, 2.91 and .30 respectively for air-conditioned and the varied temperature housing treatments. The average number of days to first estrus was 7.08 and 16.25 days for the air-conditioned and the varied temperature housing, respectively.

**FACTORS AFFECTING CALVING DIFFICULTY IN BEEF COWS.**

Susanah J. Spodee\* and K. P. Bovard. Animal Science Dept., VPI & SU, Blacksburg, Va. 24061.

Births of 4023 calves at the Front Royal Station from 1958 through 1969 were classified binomially on three traits: S (survival)—born alive, 3698, or dead, 325; A (assistance) to dam at birth—no, 3849, or yes, 174; and P (presentation)—vertex, 3962, or posterior, 61. Product-moment correlations of these traits in pairs pooled across four breeding classes were: S-A, .21; S-P, .22; A-P, .48. Calving difficulty was scored in 8 classes from the 2<sup>3</sup> arrangement of the three initial criteria. Numbers, calves' breed classifications, and average scores for calving difficulty, with a low score being desirable, were: 1340 Angus, 1.42; 1321 Hereford, 1.31; 1144 Shorthorn, 1.47; and 218 crossbred, 1.47, respectively. A biologic scale of four classes was comprised of A and criteria. An economic scale of three classes combined S with ease of calving. Breeds differed significantly ( $P < .01$ ) in ease of calving. Using the 8-point scale, calves' type of birth was not related to that of their dams,  $r = .006$ , with  $n = 1584$ . When these data were partitioned into generations within breeding classes, a few showed a statistically significant dam-offspring correlation. But, by far the majority showed a very low relationship. This indicates that the genetic influence on calving difficulty is small.

**EFFECTS OF REARING SYSTEMS ON SEXUAL DEVELOPMENT OF YOUNG BOARS.** H.R. Thomas, E.T. Kornegay and T.N. Meacham. Tidewater Research and Continuing Education Center, Suffolk, Va. 23437 and Department of Animal Science, VPI & SU, Blacksburg, Va. 24061.

One hundred and sixteen boars were used in a series of studies to determine the effect of different systems of rearing on age of puberty and libido. Boars were randomly assigned to treatment by age, weight and breed. They were exposed to gilts in heat at weekly intervals and were scored to determine age of puberty using the following code: 1 = no interest, 2 = interest, 3 = mounting without penetration, 4 = mounting with penetration and 5 = mating. Blood samples were obtained from each boar at the beginning and end of each trial and assayed to determine the levels of testosterone and androstenedione.

Eighty boars, in two separate studies, were reared as singles or in groups of 5 boars per pen. In both studies, boars raised in groups reached puberty faster than boars reared as singles.

Studies were also designed to observe the effect of group rearing in pens with and without females. There is no evidence to indicate that rearing with females increased the number of animals reaching sexual maturity nor do they reach puberty at an earlier age.

The preliminary findings suggest that sexual behavioral patterns are established very early in life, probably before birth, and once established are difficult to change.

**EXPERIMENTATION WITH AN INSECT GROWTH REGULATOR, Ro10-3108, FOR CONTROL OF THE VARIATED LEAFFOLLER, *PLATYNOTA FLAVEDANA* CLEMENS (LEPIDOPTERA: TORTRICIDAE).**

John H. Thomas, Richard W. Bagley\*, and C. H. Hill. Dept. of Entomology, V. P. I. & S. U., Blacksburg, Va. 24061, HLR Sciences, Inc., Nutley, N. J. 07110, Winchester Fruit Res. Lab., Winchester, Va. 22601.

An insect growth regulator, Ro10-3108, active ingredient 2-ethyl-3-[3-ethyl-5-(4-ethylphenoxy)-pent-1-yl]oxirane (cis/trans mixture), supplied by HLR Sciences, Inc., was tested in the laboratory and the orchard, in 1974, to ascertain its effects on variegated leafroller, *Platynota flavedana*. In the laboratory, 5 seedlings were treated with 0.1X ai. Ro10-3108(500)EC, and 5 control seedlings were treated with distilled water. Larvae were placed on each seedling and reared until all unexposed larvae developed into adults or died. In the orchard, one, two, and three applications were applied dilute using 757 cc material per 100 gallons water to single Stayman and Winesap trees replicated 4 times. Evaluations were made by checking leafrolls and fruit.

The lab experiment indicates *P. flavedana* larvae are susceptible to the effects of Ro10-3108 with 5X of the exposed larvae reaching adulthood compared to 85% of the unexposed larvae. The orchard testing indicates Ro10-3108 retards development of *P. flavedana* larvae; has a long residual life; is ineffective as a summer foliar spray because it does not reduce larval damage to the fruit.

LABORATORY PROPAGATION OF *CEUTHORHYNCHIDIUS HORRIDUS* (PANZER), AN INTRODUCED WEEVIL FOR THE BIOCONTROL OF THISTLES IN VIRGINIA. J. T. Trumble\* and L. T. Kok. Dept. of Entomology, VPI & SU, Blacksburg, VA 24061.

A colony of the introduced thistle-roseate weevil, *C. horridus* is continuously reared in our laboratory. Adults are sexed and placed in 0.4 liter clear plastic cages fitted with 25 mesh wire screen windows at the top and opposite sides. Feeding and oviposition occur on bouquets of plant material, the ends of which are immersed in a jar of water via a 1.3 cm plastic tube through the cage bottom. Cheese-cloth is wrapped firmly around the stems and prevents the weevils from falling into the water. Each cage contains approximately 20 weevils, at  $\sigma/\phi$  ratios of 3:2, with a musk thistle leaf (*Carduus nutans* L.) and a leaf of either globe artichoke (*Gynura scolymus* L.), plumelless thistle (*Carduus acanthoides* L.), or bull thistle (*Cirsium vulgare* (Savi) Tenore). Weevils are most productive when provided with musk thistle and globe artichoke, and maintained under short photoperiods of LD: 9-15 that are synchronized with day-night thermoperiods of 21-10°C. The leaves are changed weekly; the old leaves are dissected for weevil eggs.

First instars are inoculated into thistle rosettes in which a puncture is made at the growth point. Larvae are transferred using a double 'G' camel hair brush. After 6 wk, the potted plants are enclosed in polyethylene bags. Newly emerged weevils generally exhibit a positive phototaxis and are easily detected.

## Section of Astronomy, Mathematics, and Physics

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

PLASMA CONFINEMENT BY DIFFERENT MAGNETIC BOUNDARIES. J. B. Barrick\*, K. N. Leung, G. R. Taylor, S. L. Paul\*, and R. E. Kribel. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

Three types of full-line cusp geometries can be obtained by arranging permanent magnets in different orientations. When the magnetic fields are mapped using iron filings, two of the field patterns closely resemble those of the "surmac" and "picket fence". Plasma confinement by these full-line cusp geometries is studied. The efficiency in primary electron confinement is shown to account for the difference in plasma density.

SYNCHROTRON RADIATION FROM DARK CLOUDS. Robert L. Brown\* and Alan P. Marscher\*. National Radio Astronomy Observatory, Edgemont Rd., Charlottesville, Va. 22901, and Astronomy Dept., University of Virginia, Charlottesville, Va. 22901.

Interactions between cosmic-ray protons and atoms inside dark interstellar clouds produce considerable densities of relativistic electrons. Under steady state conditions, these secondary electrons can produce observable synchrotron radiation at radio frequencies. Under typical circumstances ( $B < 5 \times 10^{-4}$  gauss,  $n > 100 \text{ cm}^{-3}$ ), the observed flux density is nearly independent of the gas density inside the cloud and increases almost linearly with the magnetic field. Radio observations of the synchrotron radiation from relatively nearby dark clouds could thus enable one to determine the magnetic fields present and therefore to establish the importance of the role that such fields play in the dynamics of these objects. (The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under contract with the National Science Foundation.)



THE ELECTROSTATIC PLUME. G. E. Copeland, Old Dominion University, Norfolk, Virginia.

The electrical potential produced by a charged aerosol smoke plume diffusing in space is obtained. The plume model assumes: constant wind speed with height; different diffusion coefficients cross and down wind; plume bounce when in contact with the ground; and dispersion coefficients that are functions of down wind position and meteorological stability class. The plume model calculates the time averaged spatial mass loading  $\phi(xyz)$  as a function of position  $(xyz)$  down wind from source. The space charge density  $\rho(xyz)$  is assumed proportional to the mass concentration  $\phi(xyz)$ . The electrostatic potential function is obtained by numerical integration of Poisson's equation. Electrostatic potential maps are obtained for various cross sections through and over the plume. Application to remote sensing using airborne electrical sensors of diffusion characteristics and mass loading of plumes is suggested.

RATE OF PLASMA FLOW THROUGH MAGNETIC LINE CUSPS.

D. G. Fitzsimons\*, R. E. Kribel, K. N. Leung, and G. R. Taylor. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

A magnetic grid that generates localized full-line cusp fields is placed inside a multipole plasma device. It separates the chamber into a "driver" region in which plasma is produced and a "target" region. The rate of plasma flow through the cusps from the driver to the target side is measured by a double Langmuir probe. The saturated ion currents  $J_+$  and  $J_-$  collected in the two opposite directions at the cusp are different. The plasma drift velocity can be determined from the expression  $V = (J_+ - J_-)/ne$  where  $n$  is the plasma density and  $e$  is the electron charge.

HOLOGRAPHIC SPECTROSCOPY OF LASER DIODES. J. M. Franke\*, NASA-Langley Research Center, Hampton, VA 23665 and Dr. Jacob Becher, ODU, Dept. of Physics and Geophysics, Norfolk, VA 23508

Presented will be results from the measurement of spectra and coherence length of pulsed and continuous lasing diodes. These measurements were made by recording the wavefront autocorrelation function holographically. The autocorrelation function is reconstructed by scanning the hologram with a narrow laser beam. The spectra can be recovered by performing a Fourier Transform on the recovered autocorrelation function or by optically performing the Fourier Transform on the reconstructed wavefront from the hologram

ATLAS. L. W. Fredrick, H. E. Utiger\*. Dept. of Astronomy, Univ. of Va., Charlottesville, Va.

The Astronomic Telescope Laser Alignment System (ATLAS) is described as a fast reliable system for aligning the major optical components of an astronomic telescope. The laser is used to generate a well collimated ray which is traced through the system. The ray is aligned perpendicular to the corrector plate and there after all optical surface alignment are referenced to the corrector plate. By rotating the ray around the telescope's optic axis the reflected ray traces various patterns within the telescope on planes perpendicular to the optic axis. These patterns are interpreted as tilts or translations of the optical elements in the system. The ATLAS may be used with other types of telescopes and is adaptable for measuring other telescope parameters such as flexure of the telescope as a function of zenith angle.

A RESONANCE TUBE FOR STUDYING MOLECULAR RELAXATION IN  $N_2-H_2O$  GAS MIXTURES.† W. A. Griffin, Dept. of Physics and Geophysical Sciences, Old Dominion Univ., Norfolk, Va. 23508

A resonance tube is under development at NASA, LRC to study sound absorption in  $N_2-H_2O$  gas mixtures at ambient temperature and with frequency/pressure ( $f/p$ ) ratios in the range 0.1-1000 Hz/atm.

Current knowledge regarding the role of nitrogen in sound absorption in the atmosphere is scanty. In 1969, results of independent investigations indicated that this role might be significant.

The purpose of the present study is to determine the location of the nitrogen vibrational relaxation peak on the  $f/p$  axis as a function of humidity.

The principle of the measurement, anticipated test procedure, and tube construction are discussed.

INNOVATIVE PHYSICS TEACHING VIA TRIPLE STAGE INTERACTION MODEL. Lubna R. Ijaz, Dept. of Physics, VPI&SU, Blacksburg, VA. 24061

A new triple stage interaction (TSI) model has been developed for individualizing Physics education for greater academic achievement of each student in a classroom environment. The TSI model in brief is an attribute-task-treatment design in three stages. In the diagnostic, first stage, students' abilities and attributes were analyzed through cognitive style tests. In the second stage, students' attributes and learning styles were matched with the appropriate task. In the third stage treatment conditions were designed under which maximum learning would take place.

An introductory Physics course based on the TSI model was taught during academic year 1974-75 at Virginia Tech's Physics Dept. to sophomore students. A pretest-posttest randomized two group design was used in evaluating and comparing student achievement in the course. To motivate the students to come to class reward certificates and surprise packages were distributed occasionally. The final exam and posttest results showed that students in the TSI course (expt. group) had much superior achievement and attitude toward Physics as compared to the PSI course (control group) students. The TSI group also showed a better subject matter retention on the posttest given after ten weeks as compared to the PSI group.

† Work supported by NASA.

PLASMA LEAKAGE WIDTH OF MAGNETIC LINE CUSPS. K. N. Leung, R. E. Kribel, and G. R. Taylor. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

The effective mean free path  $\lambda$  of the primary ionizing electrons in the multidipole device can be measured for He, Ar, and Xe plasmas by inserting a negatively biased metal plate ( $\approx 100$  sq. cm) to collect ion currents. From the resulting small drop in plasma density,  $\lambda$  can be calculated. With the knowledge of the plasma flow velocity measured by a double Langmuir probe and the effective mean free path of the primary electrons, the leakage width of He, Ar, and Xe plasmas into the magnetic pole faces can be estimated by balancing the production and loss rate of the ions.

The Spreading of a Beam of Cs Ions in the Upper Atmosphere due to Scattering. D. L. Nicholson and W. B. Newbolt, Washington and Lee University. A simple exponential model of the atmosphere and the assumption that the interactions are entirely due to Rutherford Scattering have been used to calculate the level at which the mass of a 50 MeV beam of Cs ions will be deposited and the approximate size of its footprint on the atmosphere. Our results indicate that most of the mass will be deposited at an altitude of approximately 112 km and that the spot size may be smaller than .25 km.

A MULTI-LINE-CUSP PLASMA CONFINEMENT DEVICE. S. L. Paul\*, J. M. Barrick\*, D. G. Fitzsimons\*, and K. N. Leung. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

An inexpensive simple D.C. discharge plasma device is constructed from a stainless steel vessel (36 cm diam., 40 cm long) with an external system of permanent magnets (max B = 2KG). The multi-cusp field improves the plasma ion confinement time by a factor of three over a non-magnetized plasma. The primary ionizing electrons on the other hand are contained very efficiently and account for the large increase in plasma density. The uniformity and quiescence of this type of multidipole plasma will also be presented.

Photographic Technique for Analyzing the Effects

of Irradiation on a UV Converter, Cole Smith\*  
Jacob Becher, Chester Reft, Old Dominion University, Norfolk. A study was undertaken to investigate the background illumination produced in a UV converter upon exposure to electron radiation in the earth's radiation belts. A  $^{90}\text{Sr}$  source was used to simulate the flux levels. Photographs were made at various exposure times and under different shielding configurations, using various thicknesses of lead and aluminum. Electrons with an energy spectrum of .5 MeV to 1.5 MeV and below were collimated through a narrow lead slit and allowed to impact the UV converter. The UV converter consists of a MgF<sub>2</sub> window followed by a CsTe photocathode. 5000 V were used to accelerate photoelectrons from the photocathode to the P-11 phosphor screen, where observations were made. To record the low intensity background, Polaroid 3000 film was used with exposures of up to twenty-one hours. Some Bremsstrahlung radiation arising in the lead collimator was reduced by sheets of aluminum sandwiched between the lead slits, reducing the fog level. Results indicate a substantial increase in phosphor output when the high voltage is switched on. The slit image is identifiable plus the electrons seem to produce a weaker background component comparable in intensity to the Bremsstrahlung fogging but limited to the area of the P-11 phosphor. Since measurable electron activation of the converter seems to be occurring, and even low-level image contamination is undesirable, the data obtained should contribute information on shielding requirements for UV converters used in the near-earth space environment.

THE SHELL TRANSFER EFFECT IN PION REACTIONS WITH EVEN-EVEN SD-SHELL NUCLEI. C. E. Stronach and J. H. Smith\*, Dept. of Physics, Va. State Col., Petersburg, Va. 23803; B. J. Lieb, Dept. of Physics, George Mason Univ., Fairfax, Va. 22030; H. O. Funsten and W. J. Kossler\*, Dept. of Physics, Col. of William and Mary, Williamsburg, Va. 23185; H. S. Plendl, Dept. of Physics, Florida State Univ., Tallahassee, Fla. 32306; V. G. Lind\*, Dept. of Physics, Utah State Univ., Logan, Ut. 84321.

Examination of the spectra of  $\gamma$  rays taken at SREL with a Ge(Li) detector in prompt coincidence with 220-MeV  $\pi^+$ , 190-MeV  $\pi^+$ , and 0-MeV  $\pi^-$  incident on  $^{32}\text{S}$  and  $^{40}\text{Ca}$  shows large cross sections for production of the  $7/2^-$  states of  $^{29}\text{Si}$  and  $^{37}\text{Ar}$  respectively. These are anomalously large in comparison with statistical calculations relative to production of other excited states of the same daughter nuclei, and also in terms of production of  $\Delta A = 3$  daughter nuclei with respect to other  $\Delta A$  values. These  $7/2^-$  states have large (d,p) spectroscopic factors. These findings suggest that the mechanism may involve an initial reaction with an  $\alpha$  cluster, followed by recapture of a neutron, with the final-state interaction being a stripping process. (Aided by NASA grant NGR 47-014-006 and NSF grant NSF-GP-42001).

ERRORS ASSOCIATED WITH MINI-COMPUTER ANALYSIS OF MULTIDIPOLE PLASMA LANGMUIR PROBE CHARACTERISTICS. G. R. Taylor and K. N. Leung. Dept. of Physics, Madison College, Harrisonburg, Va. 22801

A simple model to analyze the Langmuir probe characteristics of a multidipole plasma using a mini-computer will be reviewed. The accuracy of the model has been tested by varying the number of input data points from the experimental probe trace. The probable error in the electron temperature, plasma density, and primary electron density will be discussed.

1. The Space Radiation Effects Laboratory is supported by the NSF, NASA, and the Commonwealth of Virginia.

## Section of Biology

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THE EFFECTS OF CROWDING AND DENSITY ON SPONTANEOUS METAMORPHOSIS IN *AMBYSTOMA JEFFERSONIANUM*. W.M. ANDERSON\*. Dept. of Biology, Old Dominion Univ., and Dept. of Pathology, Eastern Virginia Medical School, Norfolk, Virginia, 23508.

The effect of crowding (numbers in a social group) at a constant density (numbers per unit volume) was shown to retard the rate of metamorphosis and early growth in *Ambystoma jeffersonianum* larvae. Seventy three larvae (one month old) of similar size and morphology were grown in cultures containing varied numbers of animals (1.5, 10) with 1 animal per 200 ml of water. Provision for surplus food and daily replacement of water prevented competition for food and accumulation of growth inhibiting metabolites.

Measurement was made of the time elapsed from introduction into aquaria to the emergence of juveniles from the water. Snout-tail tip measurements were made after two weeks growth. Animals grown in isolation reached the selected point in metamorphosis in a mean of 33.1±5.3 days, those in groups of 5 in 42.7±8.3 days and those in groups of 10 in 42.9±6.3 days. Isolated animals averaged 6 mm longer than grouped animals after two weeks growth. The data indicates that grouping of larvae retards metamorphosis significantly ( $p < 0.01$ ) and results in a smaller mean body length ( $p < 0.01$ ) after two weeks. This experiment suggested that social and behavioral factors rather than spatial factors are involved in inhibition of metamorphosis.

THE EFFECTS OF TEMPERATURE UPON SELECTED VENTILATORY PARAMETERS OF RAINBOW TROUT, (*SALMO GAIRDNERI*). Ryland N. Arrington\*, and Cletus M. Sellers, Jr. Dept. of Biology, Madison College, Harrisonburg, Va. 22801

The effects of temperature upon ventilatory rate, ventilatory volume, and oxygen utilization were studied using rainbow trout, *Salmo gairdneri*, at 10, 15, and 20° C.

Ventilatory activity is highest at 15°C. Correspondingly the lowest oxygen utilization is also at this temperature.

The results confirm that changes in the amount of oxygen consumed by the organisms are brought about by alteration of ventilatory activity. Temperature exerts secondary effects upon oxygen utilization.

These data suggest a complex lethal chain of events initiated by temperature elevation.

Bio 2

SPONTANEOUS AND INDUCED METAMORPHOSIS IN THE BLUE-SPOTTED SALAMANDER, *AMBYSTOMA JEFFERSONIANUM*. C. G. Clayton\*, Department of Biology, Old Dominion University, Norfolk, Va., 23508

Spontaneous and induced metamorphosis was analyzed in *Ambystoma jeffersonianum* (obtained from a pond in the Shenandoah National Forest) with respect to gill and backfin reduction. Metamorphosis was induced by daily intraperitoneal injections of 1 mg. L-thyroxine ( $T_4$ ) in 25  $\mu$ l Ringer's solution (minimum effective dose to cause complete metamorphosis in the shortest period of time). Ringer's solution injections were administered to control animals. The time in hours from the onset of metamorphosis (beginning of backfin reduction) to 50% reduction of the right proximal gill rachs (GR 50) was recorded for spontaneously transforming animals (S), animals induced to transform (I), thyroidectomized animals induced to transform (T-I), and hypophysectomized animals induced to transform (H-I).

The induced groups (I, T-I, and H-I) transformed the fastest with a mean time of 92, 97, and 120 hours respectively. The S group was the slowest with a mean time of 139 hours. Since there is little difference between groups I and T-I, it suggests that injected  $T_4$  is the causing factor of metamorphosis, regardless of whether the animal's thyroid hormone acted in conjunction with the injected  $T_4$  or whether the injected  $T_4$  triggered the release of thyroid hormone through the hypothalamic-thyrotropic releasing mechanism.

Bio 4

ANALYSIS OF PIGMENTS IN THE BONE OF THE LUNGFISH *PROTOPTERUS* AND THE SHELF FUNGUS *POMES IGNIAREUS*. E.B. COLEAT, J.B. PATRICK, AND S.P. LEWIS\*, DEPT. OF CHEMISTRY, MARY BALDWIN COL., STAUNTON, VA.

In a small percentage of least African lungfish *Protopterus annectans* a blue-green pigment has been noted in both bones and mature eggs. The bone pigment was extracted with methanolic HCl and analyzed by wet analysis, ultraviolet and visible spectra. Comparative tests were made with bile pigments of lower vertebrates. The following color changes occurred in both: blue-green  $\rightarrow$  purple in conc. HCl,  $\rightarrow$  yellow in conc. HNO<sub>3</sub>,  $\rightarrow$  brown in conc. H<sub>2</sub>SO<sub>4</sub>,  $\rightarrow$  light green in conc. H<sub>2</sub>O, and remained unchanged in conc. H<sub>2</sub>O<sub>2</sub>. With spectral analysis, both peaked at  $\lambda$ 360. Since such close correlations were not obtained with purified biliverdin-dihydrochloride, it was concluded that the pigmentation in the lungfish bones is attributed to the complex of bile pigments.

The shelf fungus *Pomes igniarius* was ground and extracted with methanol to yield a mixture of organic pigments. This mixture was then extracted with petroleum ether, separating out three non-polar constituents. These were isolated and purified by silica gel column chromatography. Their characterization and analysis will be presented.

Bio 6

OXYGEN UPTAKE AND TRANSPORT IN THE RIBBED MUSSEL, *MODIOLUS DEMISSUS*. C.F. Booth\* and C.P. Mangum. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

In declining ambient oxygen, *Modiolus demissus* is a partial regulator of oxygen consumption from air saturation to a  $P_{O_2}$  of 15-30 mmHg, at which point it shuts down aerobic respiration.

Heart rate is relatively constant to a  $P_{O_2}$  of 50-70 mmHg, then it increases slightly and finally drops as the animal stops aerobic metabolism. Oxygen consumption was depressed 5% or less in animals with ligated aortas, suggesting that the blood may be of limited importance in transporting oxygen to the tissues.

Pre-branched blood from the mesosomal sinus has a  $P_{O_2}$  of 55 mmHg, which is significantly higher than the  $P_{O_2}$  (42 mmHg) of mixed pre- and post-branched blood from the heart. Pre-branched blood from the posterior adductor muscle has a  $P_{O_2}$  of 35 mmHg. These data suggest that blood may be oxygenated at the mantle and in the mesosoma, as well as at the gills, raising questions about the physiological meaning of the terms pre- and post-branched.

During exposure at low tide, *Modiolus* continues aerobic respiration by air-gaping. Blood oxygen tension and heart rate do not change during several hours of exposure to air. This ability to maintain nearly normal levels of metabolism during air exposure is not found in other intertidal lamellibranchs; it clearly contributes to the success of *Modiolus* in inhabiting the high intertidal zone.

Bio 3

UREA ACCUMULATION AND OTHER EFFECTS OF ESTIVATION IN THE AFRICAN LUNGFISH, *PROTOPTERUS*. Elizabeth B. Conant, Dept. of Biology, Mary Baldwin Coll., Staunton, Virginia 24401.

Estivation was induced in 14 lungfish. X-rays and gross measurements were taken before and after estivation and, using a modified Conway microdiffusion technique, the level of urea was measured in seven different tissues, plus blood and bile. The data show that trends in weight loss and shrinkage correlate with length of estivation. Up to 30% of the initial weight may be lost after 17 months in the mud, less after shorter periods. Of the 10-15% decrease in body length, the larger decrement was in cloaca-tail measurement compared to snout-cloaca. Pectoral limbs shrank more than pelvis, e.g., 40% vs. 25% average after 17 months. X-rays corroborate the measurement data and show that skeletal elements undergo shrinkage. Axial cartilages change during limb shortening.

Urea was found in all tissues, suggesting no storage site. Current data are summarized below, including osmolality. Data is expressed in % wet weight tissue, and in mmol/liter.

	Control	6 mos. es.	12-13 mos.	14-15 mos.	16-17 mos.
Liver	-	.78%	.92%	1.23%	
Kidney	.09%	.08%	.28%	.83%	1.47%
Muscle	.06%	.12%	.31%	.66%	1.02%
Gut	.09%	.50%	.26%	.56%	.89%
Blood	.02%	.14%	.26%	.57%	.77%
Bile	0	.08%	.60%	.64%	1.22%
Blood Usm	252.8	-	292.4	340.4	477.5
Bile Usm	-	-	352.8	471.3	444.6

The pH of blood averaged 8.3 and of bile 7.0-7.5. Bio 5

HISTOLOGICAL OBSERVATIONS OF THE REGENERATING LIMB IN THE AFRICAN LUNGFISH *PROTOPTERUS*. A. B. Conant and S. J. Thomas\*, Dept. of Biology, Mary Baldwin Coll., Staunton, Va. 24401

The limb of the African lungfish, *Protopterus*, is characterized by an axial endoskeleton composed of articulating cartilage segments and is well supplied with muscles, nerves and blood vessels. Limbs readily undergo self-replacement and recent research has given us a description of the gross morphology of the regenerate. This study extends the description to a histological level.

Following amputation in 1:1000 MS-222, regenerated tissue was removed according to specific time intervals or lengths, fixed in Bouin's and stained in H & E or a tri-chrome stain. The following patterns were observed in the regenerating tissue. Wounding epidermis has covered the stump within 26 hours in the pectoral limb and 72 hours in the pelvic. In two cases the eidermis did not cover the severed cartilage, but invaginated, expelling the terminal cartilage fragment. By approximately two weeks a thickened apical cap has formed and by three weeks there is a well developed blastema.

Cartilage does not show active growth until three weeks post amputation. Cartilage development is characterized by cell division, deposition of matrix and, ultimately segmentation. Muscles, nerves and major blood vessels appear to establish themselves in a wave following cartilage growth. By 60 days in a pectoral regenerate, all of the tissues are well established, closely resembling the original limb.

Bio 7

HABITAT PREFERENCE IN *MICROTUS PENNSYLVANICUS*: A PRELIMINARY MULTIVARIATE ANALYSIS. Walt Conley, Fisheries and Wildlife Dept., Michigan State Univ., East Lansing, MI 28824 and Alan R. Tipton\*, Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061 and Susan Kukila, Fisheries and Wildlife Dept., Michigan State Univ., East Lansing, MI 28824

Variables that relate to the inclusive habitat characteristics for the meadow vole (*Microtus pennsylvanicus*) were measured in different habitat types in south-central Michigan. One hundred and forty-eight meadow voles were snap trapped from November 1973 to May 1974. Sixteen habitat variables were measured at each successful trap site. Five variables were ultimately deleted from the statistical analysis. Variance components from the 11 variable data vectors were extracted by principle component analysis. Six varimax rotated principle components accounted for 83 percent of within row variance with eight to sixteen inch vegetative structure and percent cover and percent litter dominating the first two factors. Potential experimental manipulations based on this analysis are discussed.

Bio 8

AGE AND GROWTH OF LIGHTLY EXPLOITED POPULATIONS OF NATURALIZED BROWN AND RAINBOW TROUT IN A SMALL NORTH CAROLINA MOUNTAIN STREAM. Patrick Coulston\* and O. Eugene Vaughan\*. Va. Coop. Fishery Unit, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

86 brown and rainbow trout (*Salmo trutta* and *Salmo gairdneri*) from Poplar Creek in western North Carolina were aged using scale analysis. The absence of Lee's phenomenon in the back-calculation of lengths for older age groups suggests that both populations are lightly exploited. The absence of observed fisherman in the spring and summer of 1975 and the spring of 1976 supports this hypothesis.

Brown trout, the numerically dominant species, grew faster and lived longer than did rainbow trout (4 years vs. 5 years). Both species showed relatively slow growth with very few individuals reaching the legal size of 10 inches. No rainbow trout over 10 inches were captured.

Bio 9

TENTATIVE IDENTIFICATION OF HISTONE F<sub>1</sub> FROM TADPOLE BRAIN CHROMATIN. J. Crews\*, M. Tabb\*, and O. Stenroos. Dept. of Biology, Lynchburg Col., Lynchburg, Va. 24501.

Histones are basic proteins found in the chromatin of all eucaryotic cells. They mask segments of DNA thereby preventing RNA transcription. Five main histone groups can be extracted. Here we report on the tentative identification of the very lysine-rich fraction F<sub>1</sub> from the chromatin of brain nuclei.

Nuclei were isolated and the whole histone complement extracted from the nuclei with HCl, or the F<sub>1</sub> fraction was selectively extracted with either 5% trichloroacetic acid or perchloric acid. Electrophoresis was done on pH discontinuous polyacrylamide gels. The gels were scanned on a densitometer and the mobilities of the fractions determined.

Gels containing the total histone complement exhibited six fractions with mobilities of 57, 60, 65, 73, 76, and 83% of the mobility of the tracking dye. Gels of the histone extracts from which the F<sub>1</sub> fraction had been removed were noted to have fraction 3 (mobility 65%) missing. This was true of both the TCA and PCA extracts. The PCA extract had two fractions with mobilities of 65 and 73%, whereas the TCA extracted fractions had mobilities of 65 and 76%.

Since 5% TCA and PCA are known to selectively extract histone F<sub>1</sub>, it appears from these results that fraction 3 is the histone F<sub>1</sub> fraction.

(Aided by Lynchburg Col. Dean's Res. Council grant and Category 3 Shell Assists Program grant.)

Bio 10

ORGANIC ENRICHMENT EFFECTS UPON BENTHIC POLYCHAETE POPULATIONS. D.M. Dauer\*, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508, and W.G. Conner\*, Dept. of Biol. Univ. of South Fla., Tampa, Fla. 33620.

The effects of organic enrichment upon intertidal benthic polychaete populations of Upper Old Tampa Bay, Florida, were examined. An experimental site near a sewage outfall was compared to a physically similar control site by monthly quantitative samples from August 1974, to July 1975. Species numbers and density values for the experimental site were significantly higher than those of the control site. Species with benthic larval development were responsible for the observed density differences.

A massive accumulation of *Ulva lactuca* at the experimental site during the summer months resulted in species numbers and density values significantly lower than the control site, due to anaerobic conditions. Reestablishment of the populations was rapid at the experimental site.

Bio 11

VARIATION IN THE ECOLOGY, MORPHOLOGY AND BEHAVIOR OF THE TROGLOBITIC AMPHIPOD CRUSTACEAN *CRANGONYX ANTENNATUS* PACKARD (CRANGONYCHIDAE) FROM DIFFERENT HABITATS. G.W. Dickson, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Populations of the troglobitic amphipod *Crangonyx antennatus* living in two distinct aquatic habitats were examined for possible variations in their ecology, morphology and behavior. Collections were made seasonally for one year in six Lee Co., Va. caves, three containing mud-bottom pools and three with small gravel stream habitats. Environmental parameters thought to influence population variation were recorded in each of the six caves.

Amphipod densities, body length, female maturity, clutch number and stream washout rates were found to be greater in pool habitat populations. Variation was also observed in body coloration and antennal-body length relationships. Differences in the amount and type of available food materials found in the two aquatic habitats were considered the most important environmental parameter affecting variation in population characteristics.

The population variation of *C. antennatus* noted between habitats is viewed as indicative of the adaptive flexibility of this vagile troglobitic species.

Bio 12

SOME EFFECTS OF WATER SOLUBLE PETROLEUM PRODUCTS UPON THE CRUSTACEAN DAPHNIA PULEX.

James G. Geiger and Arthur L. Buikema, Jr. Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Water-soluble fractions were prepared from four petroleum-related products: naphthalene, phenanthrene, No. 2 fuel oil, and creosote, a well known wood preservative. Acute 96 hr bioassays were conducted at 20°C on a 16L:8D photoperiod in a growth chamber. 500 ml pyrex beakers were used for all tests, and each test beaker was aerated at approximately three bubbles per second. Five young (≈48 hr) *Daphnia pulex* were in each test container and at least 25 organisms were utilized for each concentration of a particular WSF utilized. TL-50 values are as follows:

TL-50 (48 hr) naphthalene = 55%

TL-50 (96 hr) naphthalene = 43%

TL-50 (48 hr) No. 2 fuel oil = 1.3%

TL-50 (96 hr) No. 2 fuel oil = 0.8%

Phenanthrene was virtually non-toxic and preliminary tests on creosote indicate a TL-50 value at least as great as fuel oil. These data are discussed in terms of possible interaction with various physiological parameters.

Bio 13

LEAD LEVELS IN MAMMALS AND INVERTEBRATES ASSOCIATED WITH HIGHWAYS OF DIFFERENT TRAFFIC VOLUMES. C. D. Goldsmith\*, Jr., and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Small mammals, earthworms and grasshoppers were recovered within 18 m of highways of different traffic volumes. Earthworms were recovered at 6, 12 and 18 m from highways. The study areas were as follows: (A) 23,000 vehicles/day, (B) 9,000 vehicles/day, (C) 1,000 vehicles/day, and (X) a control area in a mature forest not less than 500 m from the nearest highway. Individual mammals and pooled samples of earthworms and grasshoppers were assayed for lead using an atomic absorption spectrophotometer. Grasshoppers from Areas A and C had levels of 3.84 µg/g and 3.35 µg/g, respectively. Lead levels in earthworms decreased as distance from the road increased and were considerably less in Area C than Area A. Lead levels in shrews (*Blarina brevicauda*) were significantly ( $P < 0.05$ ) higher than in *Peromyscus leucopus* or *Microtus pennsylvanicus* from the same areas. Lead levels in mammals were significantly ( $P < 0.05$ ) higher in traffic areas than the control areas and decreased as the traffic volume decreased.

Bio 14

INFLUENCE OF CUTEREBRID INFESTATION UPON SELECT POPULATION PARAMETERS IN WOODMICE. M. S. Hensley. Div. of Natural Science, Paul D. Camp Community College, Franklin, VA 23851.

Four woodlot populations of *Peromyscus leucopus* were studied during live-trapping research over three seasons in Rockingham County, Virginia. All populations were found to be heavily infested each summer and fall by the larvae of the botfly *Cuterebra fontinella* (> 30% mean prevalence). Demographic analysis of woodmouse populations revealed that key population parameters are altered during the period of host infestation. Reduced reproductiveity was shown in adults of both sexes during infestation, a factor seemingly sufficient to damp the autumnal population rise. Infestations were repeated in 27% of the infested mice which survived for at least 30 days following larval drop. Mean range size of infested individuals decreased significantly ( $P < 0.01$ ) in comparison to pre-infestation and post-infestation sizes, due apparently to debilitation and clumsiness caused by the inguinal encapsulation sites. Cohort life tables revealed that the mean longevity of mildly infested mice is significantly greater ( $P < 0.01$ ) than in uninfested mice and in both repeatedly-infested and multi-infested mice. Emigration was monitored, and it was found to be not influencing longevity estimates. This refutes previous claims. It is suggested that increased longevity is related in an inverse fashion to range size, where the major predator is a free-ranging, random hunter. Preliminary data reinforce this hypothesis.

Bio 16

FOUR CYCLES, SIZE AND GROWTH IN *CROCONECTES INERMIS INERMIS* COPE (DECAPODA:CAMARIDAE). H. H. Hobbs III\*, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

Population studies were conducted on the troglodytic crayfish *Crocconectes inermis inermis* Cope in Fleus Cave, Lawrence Co., Indiana from 1970 to 1973. Crayfishes were individually tagged by ink injection and released in the cave, and were thus easily recognized even following ecdysis. "Marked" females ranged in size from 15.9 to 32.0 mm carapace length (cl) and the males 17.0 to 36.0 mm cl; larger and smaller unmarked individuals of both sexes were observed in various parts of the cave. Individuals demonstrated a marked decrease in growth increments with increase in length. Furthermore, for any given size, females tended to increase in length significantly more at molting than did males. Juveniles (less than 19 mm cl) demonstrated greater growth increments at ecdysis than mature forms and molted more frequently.

Two major periods of molting for adult males were observed: late Feb. to March and Aug. to Oct. Even during these peaks, the individuals near or at exuviation never exceeded 5% of the population sample. The molting period of adult females is similar to that of adult males, except the peaks occur slightly later, particularly during fall (Nov.). This lag in ecdysis seems directly related to the reproductive cycle, occurring immediately after the young of the year desert the female.

Bio 18

A COMPARISON OF BROMINE CHLORIDE AND CHLORINE INACTIVATION OF POLIOVIRUS TYPE I. Karen Zagula Haufler\*, Robert C. Bates, and Robert C. Hoehn, Depts. of Biology and Civil Engineering, VPI & SU, Blacksburg, Virginia 24061.

Viruses excreted in the feces of infected people may contaminate and survive in sewage effluents, rivers, and drinking water supplies. Chlorination for terminal disinfection of wastewater is now being re-evaluated, since the low chlorine (Cl<sub>2</sub>) residuals allowable in sewage effluents are insufficient to regularly inactivate viruses. Since the interhalogen bromine chloride (BrCl) may be a possible alternative to Cl<sub>2</sub>, a comparison of BrCl and Cl<sub>2</sub> inactivation of poliovirus type I was made. Two physical states of the virus, an aggregated polydispersed and a monodispersed state, were tested. Although polydispersed virus may be more representative of virus in nature, it is necessary to use monodispersed virus in order to determine optimum kinetics of inactivation. 20°C, 30 minute contact time, deionized water buffered to pH 7.0, and residuals of .01-.05 ppm halogen were used in each experiment. BrCl was the better virucide at all residuals tested for both kinds of virus preparations. At .02 ppm residual, BrCl resulted in a 3.5 log reduction in polydispersed virus, whereas, at the same residual Cl<sub>2</sub> resulted in less than a 1.0 log reduction in monodispersed virus and less than a 0.5 log reduction in polydispersed virus. The polydispersed virus probably was more resistant to inactivation due to the protective effect of the virus aggregation and associated proteinaceous material.

15

THE REPRODUCTIVE CYCLE OF *CROCONECTES INERMIS INERMIS* COPE (DECAPODA:CAMARIDAE) IN INDIANA. H. H. Hobbs III\*, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

The translucent carapace of *C. i. inermis* Cope allows for direct observation (in vivo) of changes in size and shape of gonads and the growth of oocytes. In addition, males experience seasonal external morphological changes that occur concurrently with ecdysis; females show no such obvious differences. Lobes of the testis are not distinctly visible through the carapace of juvenile crayfish (less than 19 mm carapace length). Just prior to the breeding season (Sept.-Dec.), the testis becomes cream-colored, and the contiguous three lobes are easily seen through the dorsal carapace. As sperm are produced, this opacity progresses distally into the three lobes and along the vasa deferentia. Copulation apparently occurs most frequently from Sept. to Dec. In Feb. and March, the ovaries are small, white and not clearly visible; not until the latter part of March and early April are oocytes obvious. By May or early June, the ovary is larger and conspicuously white. During late June and early July, it has increased in size and the oocytes are cream-colored and cement glands appear. By late July and early Aug. the oocytes are very large, yellow and easily visible; cement glands are more extensive. Ovigerous females are rarely observed but ovulation probably occurs during July, Aug. and Sept.

Bio 17

THE INTERACTION OF AFLATOXIN B<sub>1</sub> AND ZINC CARBONATE IN *MERIONES unguiculatus*. J. W. Hoffman\*, and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth University, Richmond, VA 23284.

A comparative study was undertaken involving the morphological and pathological effects of subacute levels of zinc and aflatoxin B<sub>1</sub> on male gerbils. The interactions involved three experimental groups. The experimental groups were determined by the diets fed *ad libitum* to the animals. These experimental diets consisted of aflatoxin B<sub>1</sub> at 12.8 ppm, zinc at 5,500 ppm, and a combination of aflatoxin B<sub>1</sub> (12.8 ppm) with zinc (5,500 ppm). Results indicate a possible interaction of zinc (5,500 ppm) with aflatoxin B<sub>1</sub> (12.8 ppm) involving the animal's water consumption, food consumption, change in body weight, basal metabolic rate, and differentiation of body organ weights.

Bio 19

FERTILIZATION AND PATHOLOGY IN RATS INTUBATED WITH AFLATOXIN B<sub>1</sub>. G. D. Hoke, Jr., J. W. Tawes, III\* and G. C. Llewellyn. Dept. of Biology, Va. Comm. Univ., Richmond, VA 23284.

The effects of the mycotoxin, aflatoxin B<sub>1</sub>, upon fetal development and pregnancy has been reported by others who administered the toxin orally or by injections. This study deals with low levels of the toxin being administered inter-vaginally in sterile K-Y Lubricating Jelly. The dosage levels of the mycotoxin were 0.25, 1.25, and 2.25 micrograms per breeding female. Controls showed a 80% pregnancy rate after five mating sessions of five hours each. Litter size was 10.2 ± 1.0 (mean value) and the mean fetal weight was 6.2 ± 0.2 grams in the controls. All young appeared normal at birth. With the increasing concentrations of aflatoxin there was a corresponding decrease in the percent pregnant. There was no significant change in the fetal weights and in the mean litter size compared to the controls. The data reported indicates that aflatoxin B<sub>1</sub> has only negligible effects on the development of fetuses when applied directly. There appears to be some effects on the actual fertilization as shown by the decrease in percent pregnant. Further studies are planned to evaluate the various metabolites.

Bio 20

FINE STRUCTURE OF HALLER'S ORGAN IN *IXODES BRUNNEUS* KOCH AND *IXODES FRONTALIS* PANZER (= *IXODES PARTI* LEACH). P. J. Homsher and D.F. Sonenshine. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Haller's Organ of females of two closely related species, often considered synonymous, *Ixodes brunneus* Koch and *Ixodes frontalis* Panz. were compared by scanning electron microscopy. Applying the 6 characteristics recognized by Homsher and Sonenshine for this type of analysis, the evidence indicates discontinuous trends in 4 of these characters. This finding supports the hypotheses that *I. brunneus* and *I. frontalis* are distinct species. Three new characteristics, namely size of the capsule aperture area, number and location of tarsal hump setae and, finally, size of the tarsal hump setae were also used to compare the two species. Distinct differences were found in the first and last characters providing further support for the taxonomic validity of the distinctiveness of these two forms. The potential value of SEM as an aid in the resolution of difficult taxonomic problems in the Acari is discussed. (Aided by a grant from the Southern Regional Education Board)

Bio 21

AN ANALYSIS OF THE POLYPHENOLOXIDASES OF A PURPLE MUTANT OF THE TETRASPORE ASCOMYCETE *PODOSPORA ANSERINA* NIESSL. S.P. Ivy\* and J. E. Perham. Dept. of Biology, Randolph-Macon Woman's Col., Lynchburg, Va. 24503

In the wild-type strain of *Podospora anserina* there exists two different polyphenoloxidases, tyrosinase and laccase, that catalyze reactions in melanogenesis. A melaninless mutant has been isolated that produces a purple pigment when grown in an ammonium acetate medium and a salmon pink pigment when grown in a medium containing corn meal extract. Electrophoretic and spectrophotometric analyses of enzyme extracts of the mutant strain show a polyphenoloxidase spectrum which does not differ from the wild type. Both the tyrosinase fraction and the laccase fraction of the extract catalyze the initial reactions in the synthesis of melanin *in vitro*. Therefore it is assumed that the genetic lesion blocks the synthesis of melanin after the action of the polyphenoloxidases or that the natural substrate is not available for enzyme action *in vivo*.

Bio 22

SERUM CORTICOIDS AND HEMATOLOGY OF COTTONTAIL RABBITS AS AFFECTED BY METHOD OF COLLECTION. H. A. Jacobson\* and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Comparisons were made between serum corticoids and other hematologic measurements of cottontail rabbits (*Sylvilagus floridanus*) collected by shooting and by trapping. Sixty-eight rabbits were collected by shooting and blood was collected by cardiac puncture. Blood was collected from 13 trapped rabbits by cardiac puncture following chloroform anesthesia. Mean blood measurements of shot and trapped rabbits were as follows (shot;trapped): serum corticoids (47µg/100ml; 131µg/100ml), total serum protein (7.6g/100ml; 7.6g/100ml), serum albumin (4.4g/100ml; 4.7g/100ml), serum globulin (3.2g/100ml; 2.9g/100ml), blood urea nitrogen (24.2mg/100ml; 36.7mg/100ml), total bilirubin (0.70mg/100ml; 0.51mg/100ml), direct bilirubin (0.55mg/100ml; 0.43mg/100ml) and differential leukocyte count - basophil (0.94%; 1.46%), eosinophil (1.17%; 0.46%), myelocyte (0.37%; 0.50%), juvenile neutrophil (0.50%; 0.69%), stab neutrophil (0.63%; 0.88%), segmented neutrophil (16.2%; 42.9%), lymphocyte (77.6%; 50.7%) and monocyte (1.9%; 2.5%). When tested by a Wilcoxon Rank Sum test, there were highly significant (P<0.001) differences in serum corticoids, segmented neutrophil counts and lymphocyte counts between shot and trapped rabbits. Packed cell volume and blood urea nitrogen were significantly (P<0.05) different between shot and trapped rabbits.

Bio 23

DETERMINATION OF MITOGENIC RATE AFTER SYNCHRONIZATION IN LYMPHOCYTE CULTURES. E. W. Jemison and J. W. Haywood.\* Dept. of Life Sciences, Va. State Col., Petersburg, Va. 23803.

Synchronization of lymphocyte cultures by chilling to four degrees Centigrade for one hour, was observed eighteen to twenty hours after cold shock. The lymphocyte cultures were prepared from plasma-serum fractions of peripheral blood of humans. Each plasma-serum fraction used was subcultured into three experimental and three controls. Hemacytometer counts were made at 24-hour intervals for five days. Viable counts of cells reflected lymphocyte reaction to trypan blue (.42). Cultures exposed to cold shock showed significant increase in length growth period without additional medium. (Supported by NIH grant 1 S06 RR-08090-0)

Bio 24

TOWARD A GENERAL MODEL OF LARGEMOUTH BASS POPULATION DYNAMICS by Douglas B. Jester, Jr. and Robert T. Lackey. Dept. of Fisheries and Wildlife Sci., V.P.I. & S.U., Blacksburg, Virginia 24061.

Population models generally ignore most variation in characteristics of individuals in the population and all population structure other than age and sex. Descriptions of population processes are usually time-independent rate functions. Such models are used successfully to describe populations of organisms with simple life histories living in stable environments. A new framework is necessary to describe largemouth bass population dynamics because bass have a complex life history and live in variable environments.

The new model explains changes in population structure in terms of changes in the characteristics of individuals as well as births and deaths. These processes are functions of the characteristics of the individuals involved, the structure of the population, and time-dependent environmental conditions. Several management concepts related to population structure are derived from the model by verbal argument.

Bio 25

INCREASED RESISTANCE OF MICE TO *PLASMODIUM BERGHEI* FOLLOWING PRETREATMENT WITH ENDOTOXIN. D. T. John, G. K. Vogel\* and S. G. Bradley. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298.

Bacterial endotoxin has been shown to enhance host resistance to certain infections. It may also increase susceptibility of the host if given simultaneously with the infectious agent or if administered after an infection has been established. In this study we have evaluated the capability of bacterial endotoxin and lipid A, the active component of endotoxin, to evoke increased resistance to challenge with *Plasmodium berghei* that produced fatal malaria in mice. Male DUB/ICR mice weighing 20-25 g were administered *Escherichia coli* 0127:B8 LPS (4 mg/kg) or lipid A (50 mg/kg) 24 hr before challenge with  $1 \times 10^7$  *P. berghei* NYU-2 infected erythrocytes per mouse. Mice pre-treated with endotoxin showed prolonged survival whereas mice previously treated with lipid A showed shortened survival. On day 21 the cumulative mortality was 100% for lipid A-treated mice, 75% for untreated control mice and 50% for endotoxin-treated mice. In general, erythrocyte counts, hematocrits and hemoglobin levels were reduced to a lesser degree in endotoxin-treated animals and to a greater degree in lipid A-treated animals as compared to untreated controls. Endotoxin-treated mice had lower levels of parasitemia than control mice. These results indicate that endotoxin afforded some protection to *P. berghei* infected mice whereas lipid A rendered mice more susceptible to *P. berghei* infection.

Bio 26

PRELIMINARY STUDIES ON THE DISTRIBUTION OF THE ICHTHYOFaUNA OF FAIRFAX COUNTY, VIRGINIA. Don P. Kelso\* and Cheryl F. Bright\*. Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

The fish fauna of Fairfax County, Va. is being sampled as part of the establishment of environmental baseline information prior to development of a storm water management program. Sampling has been done at 119 sites with two 1/4 inch mesh seines, one 20 feet long with a 4 foot square bag and the other 10 feet long without a bag.

The major factor affecting the distribution of a species is the physiographic separation between the Coastal Plain and the Piedmont. A second major factor is the effect of urbanization and highway construction in the stream watershed. This effect varies with each species and with the magnitude of the alteration. Thus, while many species, such as *Rhinichthys atratulus*, are widespread in their distribution, others such as *Salvelinus fontinalis*, are restricted to small areas.

Comparison of recent collections with ones made in the early 1900's reveals that the ichthyofauna of all the sampled streams has changed, most often with a loss of species in recent times. For example, *Camptostoma anomalum* is no longer found in Fairfax County.

Bio 28

PLASMA PROGESTIN LEVELS OF FEMALE WHITE-TAILED DEER DURING THE ESTRUS CYCLE. L. Kirkpatrick, R. W. Vogelsang, R. J. Warren, and F. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Three 4.5 year old, semi-tame, female white-tailed deer (*Odocoileus virginianus*) were used to determine cyclic changes in plasma progesterone levels. The deer were physically restrained and bled from the jugular vein every third or fourth day beginning on day 2 of the estrous cycle. Estrus was determined by placing the does with either an intact or vasectomized buck and the day of estrus was counted as day one of the estrous cycle. Plasma was obtained from the blood and assayed for progesterone by a competitive protein binding assay. Average concentration of progesterone for the 3 does was undetectable on days 2 and 5 (<0.25 ng/ml), rose to 0.80 ng/ml on day 9, reached a peak of 2.46 ng/ml on day 12, declined to 1.23 ng/ml on day 16, showed a second rise to 1.43 ng/ml on day 19, then declined to 0.40 ng/ml on day 23, and on to undetectable levels on day 26, which was the mean time of next estrus. In general, the magnitude, pattern of change and individual variability of progesterone levels in the does were similar to those reported for domestic sheep by Stabenfeldt et al. (1969, Endocrinology. 85:111).

Bio 30

AGGLUTINATION OF *NAEGLERIA* WITH CONCANAVALIN A. S. L. Josephson\* and D. T. John. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298.

Studies with pathogenic and nonpathogenic strains of certain amoebae including *Entamoeba histolytica* and *Acanthamoeba* have indicated differences in ability to agglutinate with concanavalin A (Con A). The ability of nonpathogenic *Naegleria gruberi* and pathogenic *Naegleria fowleri* to agglutinate with Con A was examined. Results of several experiments showed that *N. gruberi* (EGB) would agglutinate in the presence of Con A whereas *N. fowleri* (LEE) would not agglutinate. The agglutination of *N. gruberi* proved to be Con A dependent since the use of low temperatures (4°C) and  $\alpha$ -methyl-D-mannoside, a competitive Con A binder, prevented Con A-induced agglutination. *N. fowleri* would not agglutinate even at concentrations of 1 mg/ml Con A. *N. gruberi* showed visible agglutination at 1  $\mu$ g/ml Con A. The extent of agglutination and firmness of cell to cell binding was time dependent. These data indicate a virulence associated factor affecting the ability of *Naegleria* strains to undergo Con A induced agglutination and provides a potential means of quickly identifying probable pathogenicity.

Bio 27

INFLUENCE OF VARYING DEGREES OF NUTRITIONAL RESTRICTION ON VAGINAL ESTRUS AND REPRODUCTIVE ORGANS OF WHITE-FOOTED MICE. R. L. Kirkpatrick and M. H. Merson\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Forty female white-footed mice (*Peromyscus leucopus*) between 200 and 300 days of age were individually caged and randomly assigned to one of the following feeding regimes for 3 weeks: ad libitum diet; 90 percent ad libitum; 80 percent ad libitum and 20 percent ad libitum. Food used was milled Purina Lab Chow. Food consumption of the ad libitum animals was measured over 3 or 4 day intervals and the amount of food given to the restricted groups was adjusted accordingly. Vaginal smears were taken the last 8 days of treatment. The percent of each feed group exhibiting an estrous smear at least once during the 8 days was 100, 12, 10, and 10 for the four groups, respectively. Conversely, the percent exhibiting a closed vaginal orifice at least once was 20, 50, 70, and 80. Paired ovarian weights at sacrifice were 17.0, 13.7, 15.4 and 12.1 mg; uterine weights were 101, 71, 31, and 30 mg for the four respective feed groups. Body weight changes over the 3 week feeding period were -0.4, -0.2, -0.6, and -1.3 gms, respectively. Adrenal weights were not affected by feeding treatment. It appears that as little as a 10 percent reduction in food supply can cause a marked reduction in reproductive activity of captive white-footed mice. (Supported in part by PHS Grant No. R01-ES00863.)

Bio 29

THE EFFECT OF SODIUM SELLENITE ON AFLATOXIN B<sub>1</sub> TOXICITY IN GERBILS (*Morone saxatilis*). J. H. Lalor and G. C. Llewellyn. Dept. of Biology, Virginia Commonwealth Univ., Richmond, Va. 23284.

The interaction of sodium selenite with aflatoxin B<sub>1</sub> was studied. Each of four groups of juvenile, male Mongolian gerbils were fed one of four diets: control; control + 12.8 ppm aflatoxin B<sub>1</sub>; control + 5.0 ppm Na<sub>2</sub>SeO<sub>3</sub>; or control + 12.8 ppm aflatoxin B<sub>1</sub> + 5.0 ppm Na<sub>2</sub>SeO<sub>3</sub>. In all parameters studied, the control animals and sodium selenite supplemented animals showed similar trends. In both groups receiving aflatoxin, body weight, water and food consumption all appeared similar. All animals receiving experimental diets showed a decrease in growth rate. Gross pathological observations indicated some protective effect of sodium selenite against the aflatoxin treatment. This reduced effect was noted also in the histopathological examinations made on liver tissue.

Bio 31



## EFFECT OF PUMPED-STORAGE OPERATION ON SEASONAL VARIATIONS OF ZOOPLANKTON POPULATIONS.

P. H. Loeffelman\* and A. L. Buikema, Jr.  
Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Zooplankton samples were collected from 4 sites on Smith Mountain Reservoir, Va., a pumped-storage impoundment. Samples were collected once a month for one year. The effect of the operation was examined on the rotifers *Keratella cochlearis*, *Polysartha vulgaris*, *Hexarthra intermedia*, and *Conochilus dossuarius*. For the rotifers, especially *H. intermedia*, pumpback operations increased the vertical distribution of animals in the water column. This effect was most marked near the dam and may be due to the combination of turbulence and warmer temperatures at lower depths. Generally the rotifer densities near the dam were greater than those at the reference site. Possible reasons for the increase in rotifer densities include: 1) accumulation of stunned and moribund animals; 2) nutrient accumulation and increased food production; 3) warmer temperatures at lower depths; and 4) the effect of widely fluctuating temperatures on reproduction.

Bio 32

## PLASMA ANDROGEN LEVELS AND RELATED CHARACTERISTICS OF WHITE-FOOTED MICE FED A PCB. M. H. Merson\*, R. L. Kirkpatrick, and R. J. Warren\*, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Previous work (Merson and Kirkpatrick 1975, Va. J. Sci. 26(2):58) showed decreases in seminal vesicle weights and testicular spermatozoan numbers in white-footed mice (*Peromyscus leucopus*) fed a PCB. Two experiments were conducted to determine if these effects could be attributed to changes in plasma androgen levels. In the first, 49 males were singly caged and assigned to one of two groups receiving 0 or 200 ppm PCB (Aroclor 1254) in the diet for 4 weeks. In this experiment no significant effects of treatment were noted. In the second, 20 males were assigned to groups receiving 0 or 200 ppm PCB for 7 weeks, the last five of which they were paired with females. There was an apparent but nonsignificant decrease in right testis weights, spermatozoa per mg right testis and total spermatozoa per right testis of PCB-fed males. Seminal vesicle weights were significantly reduced ( $P < 0.01$ ) in the PCB-fed males ( $200.0 \pm 24.1$  and  $101.7 \pm 18.0$  mg for the 0 and 200 ppm groups, respectively) but plasma androgen levels were not ( $0.8 \pm 0.38$  and  $1.3 \pm 0.44$  ng/ml, respectively). It appears that 200 ppm PCB is marginal in producing changes in male reproductive characters and that such changes do not involve alterations of plasma androgen levels. (Supported by PHS Grant No. 1-R01-ES00863)

Bio 34

## CROP-GLAND AND GONADAL ACTIVITY IN MOURNING DOVES KILLED DURING VIRGINIA HUNTING SEASONS. R. E. Mirarchi\* and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The presence of crop-gland activity in mourning doves (*Zenaidura macroura*) of both sexes collected during hunting seasons is probably indicative of nesting activity at that time. Additionally, data on ovarian activity can provide information on the proportion of females that might have laid eggs had they survived. Crops and reproductive tracts were collected from doves on opening days of the hunting season during 1973 and 1974 (15 September and 7 September, respectively). Total numbers of adult mourning doves examined on the two sample days were: 1973, 53; 1974, 216. Total numbers of adult female doves examined were: 1973, 28; 1974, 124. The proportion of doves having crop activity was 5.7 percent and 18.0 percent respectively, for the two hunting dates while the proportion of adult females having eggs in the oviduct was 3.6 percent and 3.2 percent respectively, for the two hunting dates. No crop or breeding activity was observed in immature birds. These data indicate some mourning doves were still engaged in reproductive activities during the first week of the respective hunting seasons.

Bio 35

## SERUM CONSTITUENTS OF DECAPOD CRUSTACEA FROM THE CONTINENTAL SHELF OF THE VIRGINIAN SEA. M. P. Lynch, Virginia Institute of Marine Science, Gloucester Point, Va. 23062 and W. D. DuPaul\*, Massachusetts Maritime Academy, Buzzards Bay, Massachusetts 02532.

Organic and inorganic constituents were measured in about 500 decapod crustaceans from the continental shelf of the Virginian Sea. Species used were Geryon quinquedens, Cancer irroratus, Cancer borealis, Homarus americanus and Libinia emarginata.

Compared to *Callinectes sapidus* the coefficient of variation of the inorganic constituents Cl, Na, K and the total osmotic concentration were low (7-10%, shelf crustaceans; 40-60%, *C. sapidus*). Coefficients of variation of Cu, Zn, Ca, Mg, total protein and total lipids were similar to those of the blue crabs (40-60%). Among the five species, Cl, Na, K, Zn, and total osmotic concentration were essentially equivalent. Ca was significantly lower in Geryon and higher in Homarus. Mg was significantly lower in Homarus. Protein and Cu were significantly higher in Libinia.

Bio 33

## EFFECT OF TEMPERATURE ON THE TOXICITY OF SELECTED COMPOUND TO FRESHWATER INVERTEBRATES. Jeanne Miles\*, A. L. Buikema, Jr., and J. Cairns, Jr., Dept. of Biology, VPI&amp;SU, Blacksburg, Virginia 24061.

Static toxicity tests using heavy metals were conducted on 4 freshwater invertebrates that were preacclimated to test temperatures. Sensitivity of the animals to the toxicants varied. Copper was more toxic than zinc and chromium was the least toxic. In all cases the sensitivity in-

Animal	Metal	24hr LC-50 (mg metal/l)		
		10C	15C	20C
<i>Daphnia pulex</i>	Chromium	3.0C	1.0	0.8
	Copper	0.07	0.03	0.02
	Zinc	1.8	1.1	0.56
<i>Daphnia magna</i>	Chromium	6.0	4.8	1.0
	Copper	0.09	0.05	0.01
	Zinc	2.3	1.8	1.0
<i>Nitocris</i> sp.	Chromium	9.0	7.4	5.6
	Copper	3.2	1.8	0.56
	Zinc	5.6	3.8	2.1
<i>Philodina acuticornis</i>	Chromium	41.0	32.0	28.0
	Copper	0.43	0.38	0.21
	Zinc	1.4	0.83	0.61

creased as temperature increased. *Daphnia* were the most sensitive to chromium and copper. The rotifer, *Philodina*, was the most sensitive to zinc. The snail, *Nitocris*, was the least sensitive animal tested.

Bio 35

## AQUATIC AND SEMI-AQUATIC INSECTS OF WOODLAND POOLS IN BACK BAY. L.B.O'Hop, Jr.\*. Department of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

During the months of May, June, July and October of 1975 the aquatic and semi-aquatic insects, amphipods and isopods were collected from woodland pools in the Back Bay National Wildlife Refuge. The criteria for pool selection were depth, size, degree of shading by the surrounding trees, isolation from the bay and impoundment canal waters, and the type of habitat offered to aquatic organisms. Each pool was selected because it was different in some way from the other pools in the study.

Sampling was of a qualitative nature; however, notes on relative abundance were made during the sampling period. Some organisms exhibited specific habitat preferences as they were not found in some collection sites throughout the study period. During the dry period starting in late June and continuing through July, transitory perturbations to the distribution of aquatic organisms was noticed. As the water levels in all the pools lowered (two of the study pools were completely dry) many of the usual inhabitants of the pools were not collected. For example, the backswimmer *Notonecta* was found in large numbers in all the pools during May. As the water levels lowered, fewer specimens were collected. In July, no *Notonecta* were found in any of the pools, and this condition persisted through October. Many other aquatic insects showed similar responses to the decreasing water levels.

Bio 37

THE INFLUENCE OF VISION AND OLFACATION ON THE HOMING ABILITY OF THE WHITE-FOOTED MOUSE (*PEROMYSCUS LEUCOPUS NOVEBORACENSIS*). L. M. Parsons\* and C. R. Terman. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The purpose of this experiment was to determine the relative importance of vision and olfaction to white-footed mice while returning after displacement to a trap where previously caught. Mice were removed from a 12 acre wooded area for six days and then released at two different release points at opposite corners of the study area. Homing was measured by live-trapping during six nights subsequent to release. Nine trapping periods were conducted over a nine month period. Mice were blinded by bisection of the optic nerve and were made anosmic by nasal injections of  $ZnSO_4$ . Both anosmic and saline-injected controls were tested in an olfactometer.

The percentage of intact, blind, anosmic and saline-injected mice which homed did not differ significantly from each other. Experience (previous release) at a release site increased the percentage homing. Blind mice had a significantly poorer ( $P < 0.05$ ) survival during the six days subsequent to release than mice of the other treatments, while the latter did not differ significantly among themselves.

Bio 38

OXYGEN UPTAKE AND TRANSPORT IN THE GASTROPOD, *BYSSON CANALICULATUM* AT DIFFERENT SALINITIES. G. POLITES\* and C.P. MANNING. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

The  $O_2$  affinity of the blood pigment hemocyanin, of *Bysson canaliculatum*, changes in response to alterations in the ionic concentration of the blood. Increasing salt concentration depresses  $O_2$  affinity while increasing  $H^+$  ion increases  $O_2$  affinity. *Bysson* is an ionic and osmotic conformer remaining slightly hypotonic and hyperosmotic over a salt range of 16-3‰, at least under normoxic conditions. The fluctuating ionic environment of the estuary thus poses respiratory problems for this ionic and osmotic conformer.

Whole animal respiration was measured in declining ambient oxygen at high and low salinity and at 21.07 and 23‰. A gradual shift from conformity to partial regulation of oxygen consumption in response to declining ambient  $pO_2$  is consistent with the pattern in other large gastropods. At 23‰ and 10‰ high salinity oxygen consumption is greater than low salinity values but, at 6‰ this pattern is reversed. The possible ionic and mechanistic explanations will be discussed.

Blood  $pO_2$  was measured in various location showing gradual oxygen depletion along the circulatory route. The changes in  $pO_2$  are attributable to both the activity state as well as the ionic concentration of the blood.

Bio 40

THE FOOD OF CENTRARCHID FISHES ASSOCIATED WITH ARTIFICIAL TIRE REEFS IN SMITH MOUNTAIN LAKE, VIRGINIA. E.D. Prince\*, T.E. Maughan\*, and G. L. Clement\*. Dept. Fish. and Wildl. Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The stomachs of 90 largemouth bass, 87 smallmouth bass, 99 large bluegill, and 111 small bluegill were collected from specimens taken around the artificial tire reefs in Smith Mountain Lake, Va., from June through October 1975. Reef fishes utilized the tire reef areas as a feeding station. Bass fed mostly on bluegill, however, they can be best categorized as opportunistic piscivorous carnivores. Bluegill fed primarily on plant material, Dipteran larvae, and bryozoans and are best categorized as opportunistic omnivores. White catfish eggs and fry were an important bluegill food in August.

The addition of tire reef substrate provided additional attachment surface for aquatic macroinvertebrates and algae, and a site for deposition of white catfish eggs. These organisms were utilized directly by reef fishes as food. Installation of artificial tire reefs altered the availability of food to localized fish populations and subsequently shortened and modified the typical lentic food web in isolated areas of Smith Mountain Lake, Virginia.

Bio 42

OVARIAN ACTIVITY AND PROGESTIN LEVELS IN FEMALE TYLOMYS. T. A. Pierson\*, P. P. Scanlon, F. C. Gwazdauskas\*, and P. L. Dalby. Depts. of Fisheries and Wildlife Sci. and Dairy Sci., Va. Polytech. Inst. and State Univ., Blacksburg, and Dept. of Biology, Univ. of Virginia, Charlottesville.

Previous studies of reproductive organs of female *Tylomys* indicated that large numbers of corpora lutea (range = 10 - 29) were present in the ovaries (Haas, Dalby, and Scanlon, Virginia J. Sci. 26:55, 1975). The present study was intended to extend knowledge of ovarian function and progestin levels of *Tylomys* in comparison to laboratory rats. Estrous cycles were established for 4 cycling *Tylomys* by vaginal smearing. Mean ( $\pm$  SE) cycle length was 6.86 ( $\pm 0.39$ ) days. Interval to first postpartum estrus was 6 and 7 days in 2 *Tylomys*. Mean ( $\pm$  SE) number of corpora lutea in 6 *Tylomys* was 27.17 ( $\pm 2.87$ ). Progestin levels (competitive protein binding assay) determined from blood serum samples taken at sacrifice of *Tylomys* ranged from 0.3 to 3.17 ng/ml (mean = 1.004 ng/ml). All animals were diestrous. Mean number ( $\pm$  SE) of luteal structures in 12 cycling laboratory rats was 15.25 ( $\pm 3.07$ ). Progestin levels ( $X \pm SE$ ) in rats were: proestrus (11.34  $\pm$  2.4, 2); estrus (9.11  $\pm$  3.62, 6); diestrus 1 (23.8, 1); and diestrus 2 (10.21  $\pm$  3.63, 3). Progestin levels in *Tylomys* were considerably lower than in laboratory rats despite the much higher number of luteal structures.

Bio 39

SURGICAL PROCEDURES FOR IMPLANTING ULTRASONIC TRANSMITTERS INTO SMALL FISH. E. D. Prince\* and D. B. Jester, Jr. Dept. Fish. and Wildl. Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Telemetric observation of sunfish was impractical in the past because small, long-lived transmitters were not available. A Chipman transmitter, modified by adding a battery case and lowering transmission frequency to 0.5 pulse per second, was used to monitor movement of sunfish in Smith Mountain Lake, Virginia, for periods up to 35 days. This transmitter was 2.8 mm x 18 mm x 8 mm, weighs 9.2 gms in air, 5.5 gms in water, and displaces 3.8 ml. With the following modifications of standard surgical procedures, the modified transmitter was successfully implanted into the peritoneal cavity of sunfish greater than 195 mm total length: (1) minimal anesthesia (20 mg/1 quinaldine); (2) a J-shaped incision beginning about 2 mm posterior to the pelvic girdle and extending back at least 20 mm, then curving slightly into the lateral musculature just anterior to the anal orifice; and (3) wider sutures, passing through the peritoneum and integument 8-10 mm from either side of the incision. These modifications helped avoid additional stress from anesthesia, necrosis due to cutting of vascularized tissue in the pelvic girdle, rupturing of the anal sphincter during insertion of the transmitter, and reopening of the incision by internal pressure.

Bio 41

EFFECTS OF ENVIRONMENTAL FACTORS ON LARVAL DEVELOPMENT OF THE GRASS SHRIMP, *PALAEMONETES PUGIO*. A.J. Provenzano, Jr., J. Goy\*, and K. Schmitz\*. Inst. of Oceanography, Old Dominion University, Norfolk, Va. 23508.

*Palaemonetes pugio*, a dominant species in east coast tidal marshes plays a major role in breakdown of detritus and flow of energy through the marsh. Study on effects of environmental factors on larval development can be strongly influenced by variables in laboratory rearing. A series of experiments to define laboratory conditions necessary for consistent rearing results is being carried out prior to initiation of toxin bioassays. This series has not yet resulted in definition of such conditions. Temperatures near optimum result in stranding mortalities which can be eliminated by addition of polyethylene oxide to the medium. Such addition appears to otherwise enhance survival in artificial sea water, but not in natural river water. When temperature and salinity are constant, quality and quantity of *Artemia* used as food affects survival rate, regularity of molting, and duration to metamorphosis with *Artemia* from some sources clearly superior to that from others. Concentrations of *Artemia* nauplii below 10/ml for one zoea in 25 ml of water inhibit growth. Variability in quality of river water may result in superior or inferior results relative to artificial sea water. Genetic or other quality variations between individual broods of larvae may also account for significant variations in larval duration and/or survival rates. Such variability must be eliminated from routine rearings prior to laboratory assays.

GENETIC COUNSELING: A SURVEY OF STUDENT KNOWLEDGE AND ATTITUDES. Robin L. Bush\* and Dr. Beverly F. Silver, Dept. of Biology, Madison Co., Harrisonburg, Va. 22801.

A survey was distributed among students of all years on the Madison College Campus to determine knowledge and attitudes about genetics and genetic counseling. The results showed that students are somewhat aware of the problems that genetic defects present to society and that some students are adequately educated about the genetic mechanisms involved in producing birth defects. Attitudes towards techniques available in genetic counseling are varied and need to be changed if genetic counseling is to be optimally effective in preventing birth defects. Some solutions to the problem are suggested.

Bio 44

CYTONEUTIC ANALYSIS OF MITOGENIC AND MUTAGENIC RESPONSES OF HUMAN LYMPHOCYTES TO CALCIUM CYCLAMATE. B.A. Rivers and E.W. Jemison, Dept. of Life Sci., Va. State College, Petersburg, Va. 23803.

Lymphocyte response in vitro to calcium cyclamate is being determined in cultures of peripheral blood from plasma-serum fractions collected in sodium citrate tubes. Measures of mitogenic activities at 24hrs., 74hrs., 72hrs., and 792-hrs. by hemacytometer counts are compared with that of the controls. From these data, growth curves are plotted and analyzed. Preliminary results indicate the maximum peak of cell counts occurs at 72hrs. incubation, which suggests the critical time to inoculate cyclamates into the lymphocyte culture. The introduction of cyclamate into the culture medium seems to assure stability of the lymphocyte culture and increases the mitogenic rate of lymphocytes. Mutagenicity and cytogenetic effects after five hours exposure to calcium cyclamate are determined by karyotyping metaphase spreads. The statistical interpretation of results are computed on the basis of analysis of covariance and the application of the T-test. (Supported by Minority Biomedical Support Program, NIH grant, 1 S06 RR-08090-0)

Bio 45

REPRODUCTIVE CHARACTERISTICS OF WOODCHUCKS IN SOUTHWEST VIRGINIA. S. W. Ruckel\*, P. F. Scanlon, and R. L. Kirkpatrick. Dept. Fisheries and Wildlife Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Reproductive data from woodchucks were collected in southwestern Virginia during the periods March 13 to May 13, 1974 and 1975. Emergence from hibernation was estimated to have begun during the second week of February. Peak breeding activity appeared to occur during the first two weeks of March. Mean corpora lutea per female, placental scars per female, and paired ovarian weights and percentage of females which ovulated were significantly ( $P < 0.05$ ) greater for adult females than yearlings. The mean plasma progesterin level for yearling females was significantly ( $P < 0.05$ ) higher than that of adult females. Paired testes and paired epididymides weights were significantly ( $P < 0.05$ ) greater in adult than in yearling males. Plasma androgen levels were similar in adult and yearling males. Supported in part by McIntire-Stennis Project No. 636201.

Bio 46

AGE, WEIGHT, AND HEART GIRTH RELATIONSHIPS IN WHITE-TAILED DEER Fawns. M. D. Russell\*, R. W. Vogelsang\*, R. J. Warren\*, P. F. Scanlon, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ. Blacksburg, Va. 24061

Body weight and heart girth measurements were collected from twenty-one white-tailed deer (*Odocoileus virginianus*) fawns (1 to 30 days old) during the interval 2 June to 23 July 1975, resulting in a total of 287 observations. The fawns were born to captive does at the deerpen facilities at VF64SU and were subsequently raised by their dams. Ten fawns were twins; 11 were singles. Data were analyzed by analysis of variance. Age, weight and heart girth relationships were all highly correlated. Correlation coefficient ( $r$ ) for the following relationships were: age-weight ( $r = 0.86$ ), age-heart girth ( $r = 0.86$ ), weight-heart girth ( $r = 0.97$ ). Using an inverse regression procedure with age being held as the dependent variable, the following model was developed. Age (days) =  $-34.769 + [2.488 \times \text{heart girth (ins)}] + [0.855 \times \text{weight (lbs)}]$ . Seventy-six percent ( $r^2 = 0.76$ ) of the variation was explained by this model with the remaining error causing a 95% confidence interval of approximately  $\pm 8.9$  days. Using a regression procedure with weight as the dependent variable, another model was developed. Body weight (lbs) =  $-22.559 + [2.378 \times \text{heart girth (ins)}]$ . For this model  $r^2 = 0.93$  and 95% C.I. =  $\pm 2.23$  lbs. [Supported by McIntire-Stennis project 636201.]

Bio 47

CELL SPECIFIC EVENTS OCCURRING DURING DIFFERENTIATION OF DICTYOSTELIUM DISCOIDEUM. C. L. Rutherford, J. F. Harris, B. L. Jefferson, and J. B. Wilson. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Ultra-microfluorometric techniques were adapted to follow several compounds related to energy metabolism through the developmental cycle of *Dictyostelium discoideum*. Each compound (ATP,  $\text{NH}_4^+$ , trehalose, trehalase, and glucose) was found to be present in stalk and/or spore cells.

The accumulation of  $\text{NH}_4^+$  was interpreted as an indication of protein degradation, a source of energy in this organism. During the early stages of differentiation  $\text{NH}_4^+$  was localized only in prestalk cells. However, it accumulated in spore cells during culmination such that levels were comparable in the two cell types by the end of development.

Trehalase, an energy source for germinating spores, was found in both cell types but was preferentially degraded by trehalase in stalk cells late in development. The degradation product, glucose, was localized in stalk cells as was trehalase.

ATP, which is directly related to energy charge, was not localized in a specific cell type.

These findings emphasize the need for knowledge of cell-specific events involved in differentiation.

This research was supported by the Brown-Hazen Fund of Research Corporation.

Bio 48

THE TOXICITY OF COMBINATIONS OF VARIOUS METAL WASTE PRODUCTS TO ROTIFIERS. C. See\*, A. L. Bullock, Jr., and J. Cairns, Jr. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Philodinae were acclimated to 20°C and a 12L:12D photoperiod for 72 hours prior to testing. Experiments were conducted in triplicate at each concentration for 24, 48, and 96 hours. EC50 values were obtained for  $\text{Zn}(\text{ZnSO}_4 \cdot 7\text{H}_2\text{O})$ ,  $\text{Cr}(\text{K}_2\text{Cr}_2\text{O}_7)$ ,  $\text{Cu}(\text{CuSO}_4 \cdot 5\text{H}_2\text{O})$ ,  $\text{Fe}(\text{FeSO}_4 \cdot 7\text{H}_2\text{O})$ ,  $\text{Zn}(\text{NaF})$ , and  $\text{ch}(\text{NaCl})$ . Using these EC50 values, combination experiments were set up as follows in triplicate for each time period: controls; toxicant 1 at EC50 value; 80% toxicant 1, 20% toxicant 2; 60% toxicant 1, 40% toxicant 2; 50% toxicant 1, 50% toxicant 2; 40% toxicant 1, 60% toxicant 2; 20% toxicant 1, 80% toxicant 2; toxicant 2 at EC50 value. Antagonism was shown in the following combinations: Zn + Cu, Zn + fluoride, Fe + fluoride, Cu + fluoride, Zn + chlorine, Fe + chlorine, fluoride + chlorine. Synergism was demonstrated in the Cr + chlorine combination. The effects were additive for the following combinations: Cu + Cr, Cr + fluoride, Cu + chlorine.

Bio 49

## INSECTS OF PARAMORE ISLAND - A PRELIMINARY SURVEY.

Jay C. Shaffer\*, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

An insect trap utilizing a 15w fluorescent lamp and a calcium cyanide charge was run for two consecutive nights, July 1 & 2, 1975, on the north end of Paramore Island (a large barrier island near Wachapreague, Accomack Co., Va.) at the forest-dune community interface. The several hundred specimens (mostly Coleoptera, Lepidoptera, and Diptera) collected have been contributed to the Smithsonian Institution.

Several species of particular interest were found. *Coenochroa bipunctella* (Pyralidae) is a new state record (previously only five specimens were known north of Florida). *Ecritothrix trimaculella* (Tineidae) is a tiny moth, thought to be myrmecophilous. *Acenotropus* (Pyralidae) is an unusual find as this moth is associated with fresh water streams and rivers.

Bio 50

THE OCCURRENCE OF *NEOFIBER ALLENI* IN SUGAR CANE FIELDS OF THE UNITED STATES SUGAR CORPORATION AT CLEMONSTON, FLORIDA. D. E. Steffen\* and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The Florida water rat, *Neofiber alleni*, is one of several species of rats that damage sugar cane in south Florida. In sugar cane fields *Neofiber* typically live in distinct burrow systems scattered irregularly throughout infested fields. Many of the individual burrow entrances within these systems exhibit obvious mounding of dirt from tunnel excavations. These mounds are easily seen from a distance. From 12 January 1976 to 22 March 1976, 237 or approximately 26% of all fields harvested during the 1975-1976 harvest season in the Western Division of the United States Sugar Corporation were randomly selected and examined after harvest for the relative abundance of *Neofiber*. Relative abundance was determined by the enumeration of burrow systems in each field surveyed. The mean size of all survey fields was 35 acres (range = 3-76 acres). The 32,300 acres harvested in the Western Division represents about 10.8% of Florida's total sugar cane crop. Of the fields examined, 41% had evidence of burrowing activity. Distribution of *Neofiber* occurrence between fields appeared neither random nor normal. The mean number of burrow systems per acre in infested fields was 0.28 (range = 0.02 - 1.39; median, 0.12. [Supported by U.S.D.-I. Fish and Wildlife Service and the Florida Sugar Cane League.]

Bio 52

BEHAVIORAL AND REPRODUCTIVE CONSEQUENCES OF BRIDGING ASYMPTOTIC LABORATORY POPULATIONS OF PRAIRIE DEERMICE. B. Swanson\* and C. R. Terman. Lab. of Endocrinology and Population Ecology, Biology Dept., Col. of William and Mary, Williamsburg, Va. 23185

Enclosed laboratory populations of prairie deer mice, *Peromyscus maniculatus bairdii*, under conditions of unlimited food and water, do not continue to grow indefinitely, but show a sigmoid-type growth curve. The plateau in population growth, or asymptote, is characterized by failure of young to survive or by cessation of reproduction, more frequently the latter. A large proportion of adult animals in asymptotic populations are not reproductively mature. Numerical densities at which asymptote is reached vary widely among populations, leading to the hypothesis that population growth is not limited by density *per se*, but is influenced greatly by the social structure within the population. In this study, experimental asymptotic populations were bridged together in pairs and a control population was bridged to an empty pen. Behavior observations showed that bridging was accompanied by a rapid re-structuring of the social organization in experimental populations, followed by a large increase in the proportion of reproductively mature animals.

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RADIOECOLOGICAL STUDIES OF THE SQUIRREL FLEA ORCHOPHEAS HOWARDI IN LABORATORY AND FIELD COLONIES OF THE SOUTHERN FLYING SQUIRREL *GLAUCOMYS VOLANS*. D.E. Sonenshine and D.M. Lauer\*. Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508

Radioecological studies of the population dynamics of the squirrel flea *Orchopheas howardi* in laboratory and field colonies of the flying squirrel *Glaucomys volans* were initiated following implication of this arthropod as a vector of sylvan epidemic typhus. Fleas were radiolabelled internally by feeding them on flying squirrels injected with  $^{14}\text{C}$ ,  $^{32}\text{P}$ ,  $^{36}\text{Cl}$  and combinations of these isotopes and externally by binding  $^{125}\text{I}$  to cuticle proteins through gaseous diffusion. Although some internal label was lost through bioelimination, labelled fleas remained detectable throughout the experimental period. There was no transference of label between fleas by contact or trans-ovarial transmission, and the labels had no noticeable effect on flea survival or viability. Mark and recapture studies in a laboratory colony of approximately 30 flying squirrels under constant ambient temperature and relative humidity indicated a total population of 4965 fleas (S.E. = 1034) and extensive nest-to-nest interchange of fleas. Mark and recapture studies in a wild flying squirrel population are currently in progress.

Bio 51

CREATINE PHOSPHOKINASE AND MUSCLE CELL DIFFERENTIATION IN VITRO. William M. Sutherland\*, and Irvin R. Konigsberg. Dept. of Biology, Univ. of Va., Charlottesville, Va. 22901.

The fusion of myogenic cells *in vitro* is a response to changes in the culture media (and the time of initiation of fusion can be manipulated by controlling the level of high molecular weight growth factors). Media recovered from cultures of differentiated muscle cells, when fed to cultures of unfused embryonic myoblasts, promotes fusion and the subsequent withdrawal of myocyte nuclei from the cell cycle, while the reduction of  $\text{Ca}^{++}$  in the medium prevents myoblast fusion, although these cells also eventually withdraw from the cycle. This raises the question: is fusion a necessary prerequisite to all of the molecular changes associated with myogenic differentiation? Changes in creatine phosphokinase (CPK), which mark the differentiation of muscle cells, was examined in both myocytes and low  $\text{Ca}^{++}$  blocked myoblasts using a sensitive fluorometric enzyme assay. Such data is expressed either per nucleus or per microgram DNA, depending upon whether clonal or mass cultures are used. In addition, the degree of fusion in mass cultures is determined by differential counts of syncytial and myoblast nuclei. These experiments compare the accumulation of CPK between normally fusing cultures and fusion-blocked cultures in an attempt to determine the relationship between fusion, DNA synthesis (or cell division) and the development of CPK levels characteristic of differentiated cells. (Supported by NIH grant # HD 07083).

Bio 53

CHANGES IN PACKED CELL VOLUME AND PLASMA PROTEIN OF MALE WHITE MICE FOLLOWING ADMINISTRATION OF METHOXYFLURANE. I. R. Teit\*, P. F. Scanlon, and J. A. Wesson III\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

One hundred male mice (*Mus musculus*) were divided into 5 groups (20 mice each) four of which were exposed to an inhalant anesthetic (Methoxyflurane: Metaphane, Pitman-Moore). Groups of mice were exposed to Methoxyflurane for periods of 15, 30, 60, or 120 minutes following which they were killed by decapitation and exsanguinated. Packed cell volumes (PCV) and plasma protein values were determined for each mouse. Controls were handled similarly to treated animals, except for exposure to methoxyflurane. PCV and plasma protein was determined for controls following killing and exsanguination. Mean PCV ( $\pm$ S.E.) for controls, 45, 30, 60, and 120 min. exposure groups were 47.0 ( $\pm$ 0.77), 44.45 ( $\pm$ 0.42), 46.85 ( $\pm$ 0.99), 43.35 ( $\pm$ 0.57), and 44.35 ( $\pm$ 0.61), respectively. The mean plasma protein levels ( $\pm$ S.E.) for the above groups were 6.76 ( $\pm$ 0.11), 6.18 ( $\pm$ 0.09), 6.24 ( $\pm$ 0.11), 5.80 ( $\pm$ 0.09), and 5.89 ( $\pm$ 0.08). PCV was significantly ( $P<0.05$ ) lower than controls in all groups except those exposed to Methoxyflurane for 30 minutes. Plasma protein levels were significantly ( $P<0.05$ ) lower than controls in all treated groups. The 60 and 120 minute groups had significantly ( $P<0.05$ ) lower plasma protein values than 15 and 30 minute groups.

Bio 55

# LABORATORY STUDIES OF POPULATION REGULATION IN PRAIRIE DEERMICE. C. Richard Terman. Laboratory of Endocrinology and Reproduction, Ecology, Biology Department, College of William and Mary, Williamsburg, Va. 23185

Laboratory populations of Prairie Deer mice when supplied with surplus food, water and harborage, do not increase indefinitely but rather their growth is regulated at markedly varying densities under identical conditions of the physical environment. In spite of variable numerical levels of asymptote, the component animals of such populations exhibit similar physiological and anatomical characteristics, among which is inhibition of reproductive maturation and function in 80-95% of the mice born into the populations.

Control of growth is achieved by either complete cessation of reproduction or mortality of young. Mice born into populations in which growth was controlled by cessation of reproduction had significantly smaller ovaries, uteri, testes, vesicular glands, and bacula and a significantly smaller percentage ovulated than those in populations whose growth was regulated by mortality of young. Animals from populations regulating by both mechanisms had significantly smaller reproductive organs and reproductive rates compared to control mice maintained as bisexual pairs. These and other data suggest that intrapopulation communication having physiological as well as behavioral effects is involved in growth regulation and that laboratory populations should be regarded as entities distinct from each other.

Bio 56

# VANILMANDelic ACID LEVELS IN WHITE-TAILED DEER. D. F. Urbinson\* and P. F. Scanlon. U.S.D.A. Forest Service, Columbia, S.C. and Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

Vanilmandelic acid (VMA) is a metabolic product of the catecholamines, epinephrine and norepinephrine. VMA can be measured in blood or in urine. In white-tailed deer (*Odocoileus virginianus*) it was found that VMA could be measured with reasonable precision in urine samples. Urine was collected from 65 deer fawns from two distinct areas, Swamp and Upland, having different patterns of reproduction on the Savannah River project, Aiken, South Carolina. Urine VMA levels did not differ significantly between areas. Urine from deer killed during hunting by two methods (hunting with dogs and still hunting) was also assayed for VMA. VMA levels were significantly ( $P < 0.05$ ) higher in deer killed following chasing by dogs. Mean VMA values were 6.48  $\mu\text{g/ml}$  (N=13) and 5.42  $\mu\text{g/ml}$  (N=19) for deer killed during hunting with dogs for Swamp and Upland areas, respectively. Means were 2.88  $\mu\text{g/ml}$  (N=9) and 3.60  $\mu\text{g/ml}$  (N=23) for still hunted deer from the Swamp and Upland, respectively.

Bio 57

# WINTER FOOD CONSUMPTION OF WHITE-TAILED DEER ON TWO LEVELS OF ENERGY. R. W. Vogelsang\*, R. L. Kirkpatrick, and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Daily food consumption was recorded for twenty-six female white-tailed deer from 29 October 1975 through 11 February 1976. At the initiation of the study all animals (18 adults and 8 fawns) were weighed and placed on one of two pelleted rations. Each one contained 13.8 percent crude protein, but the low energy ration contained only 76 percent of the digestible energy (D.E.) of the high energy ration. Four of the low energy adults had eaten most of their hair early in the study providing an opportunity to study the effect of hair coat insulation on food consumption and hence these 4 animals were considered separately. Average weekly food consumption (kg/deer/week) for high and low energy fawns was 5.99 and 8.28, respectively. High energy adults averaged 7.46 compared to 9.21 for low energy adults with hair and 12.45 for low energy adults without hair. The average weekly D.E. intake (kcal/deer/week) was 19,094 for high and 20,411 for low energy fawns, while the D.E. intake for high energy adults was 24,229 compared to 22,705 for low energy adults with hair and 30,670 for low energy adults without hair. The average weight change (kg) for an 11 week period was 7.0 and 4.7 for high and low energy fawns and -1.6 for high energy adults, -1.0 for low energy adults with hair, and -1.5 for low energy adults without hair.

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# INFLUENCE OF LEVEL OF ENERGY INTAKE IMMEDIATELY PRIOR TO BREEDING ON FAWN PRODUCTION IN WHITE-TAILED DEER. R. W. Vogelsang\*, R. J. Warren\*, R. L. Kirkpatrick, and P. F. Scanlon. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Twenty yearling female white-tailed deer (*Odocoileus virginianus*) were randomly assigned to one of two energy intake levels on 8 October 1974. Animals on the high energy diet received 1 kg of cracked corn per day (3800 kcal) and those on the low energy diet received one-half this amount. All animals also received orchard grass hay and water throughout the study. Beginning on 5 November 1974 each of the does was singly introduced into a 3.65 x 7.30m sheltered pen with one of three yearling males. This procedure was repeated daily through 3 January 1975 at which time 18 of the 20 does had exhibited estrus and mated. Only 60 percent of the low energy does were productive compared to 90 percent of those on the high energy diet. Low energy does produced a total of 7 fawns with only 1 set of twins compared to a total of 14 fawns and 5 sets of twins for the high energy does. The number of fawns per pregnant doe was 1.17 and 1.55 for the low and high energy does, respectively. The average weight change (kg) for the first 9 weeks of the study for the low energy does was -1.11 compared to 1.97 for the high energy does.

Bio 60

# ENZYME POLYMORPHISMS AND GENETIC VARIATION IN THE BAY SCALLOP, *Argopecten irradians*. J. F. Wall, Sarah W. Wall and N. Castagna. Dept. of Biology, George Mason Univ., Fairfax, Va. and Virginia Institute of Marine Science, Wachapreague, Va.

The bay scallop is a hermaphroditic marine pelecypod distributed disjunctly in sheltered bays near the ocean on the Atlantic and Gulf coasts of the United States. We have examined a singled population from Bogue Sound, N. C., for genetic variation at 15 loci. Allelic variation was found at 5 loci: *Pgm-1*, *Pgi-1*, *Got-2*, *Lac-1* and *Lac-2*. Goodness of fit to Hardy-Weinberg equilibrium ( $\chi^2$ ) indicates significant heterozygote deficiencies at the *Got-2* ( $D = -0.685$ ,  $P < 0.001$ ) and *Lac-1* ( $D = -0.398$ ,  $P = 0.05$ ,  $P > 0.025$ ) loci. All other polymorphic loci are in equilibrium. The most polymorphic loci were *Pgm-1*, 5 alleles ( $n = 3$ ) and *Pgi-1*, 5 alleles ( $n = 2$ ). In this population there were 33.3% polymorphic loci; the percentage heterozygous loci per individual was  $11.6 \pm 6.9$ . (Supported by The George Mason Univ. Foundation and Sea Grant, subcontracted from VIMS).

Bio 61

# REPRODUCTION IN FEMALE COTTONTAIL RABBITS AS INFLUENCED BY MIREX INGESTION AND NUTRITIONAL RESTRICTION. R. J. Warren\* and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Reproductive characteristics of 29 female cottontail rabbits (*Sylvilagus floridanus*) were observed in a 2X2 factorial experiment in which 20 ppm dietary Mirex and 25% nutritive restriction were employed as treatments. The animals were singly-caged during an 8 week laboratory treatment period following which they were released into four 0.1 ha outdoor enclosures with 16 males for a period of 3 weeks for mating to occur. Mirex treatment was discontinued while the rabbits were outside. Results indicated that Mirex, at levels used in this experiment, did not adversely affect the reproductive characteristics observed. Only 18% of the rabbits on restricted diets had ovulated and were pregnant, whereas 100% of the ad libitum rabbits had ovulated and 80% were visibly pregnant. Ovulation rates were not significantly different when only rabbits which had ovulated were compared. However, the number of fetuses per pregnant female was significantly ( $P < 0.05$ ) lower in the feed-restricted group. Restricted rabbits also had significantly ( $P < 0.01$ ) lighter ovarian weights than ad libitum rabbits. (Supported by PHS Grant No. R01-ES00863)

Bio 62

## TESTES WEIGHTS AND SPERMATOZOAN NUMBERS IN EASTERN

MEADOWLARKS (*STURGEONELLA MAGNA*) AND RED-WINGED BLACKBIRDS (*AGELAIUS PHOENICEUS*) IN RELATION TO SEASON. J. A. Messon III\*, H. L. Ferguson\*, C. S. Addison\*, and P. F. Scanlon. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Five male red-winged blackbirds (RW) and five male eastern meadowlarks (ML) were sacrificed during March, April, and May. Paired testes weights increased significantly ( $P < 0.05$ ) in both species from March to April and May (RW-March, 18.3 mg; April, 365.7 mg; May, 611.4 mg; ML-March, 167.0 mg; April, 626.3 mg; May, 690.3 mg). Spermatozoan numbers were determined by a modification of the method of Amann and Alquist (1961; J. Dairy Sci. 44:1537). Spermatozoan numbers increased concurrently with testes weight increase (sperm/mg testis  $\times 10^5$  = RW-March, 0.00; April, 0.70; May, 0.66; ML-March, 0.42; April, 1.50; May, 2.08). Only two ML and no RW had spermatozoa during March. ML had significantly greater spermatozoa/mg testes than RW during April and May.

Bio 63

INCREASE IN PROGESTIN AND ESTRONE LEVELS IN WHITE-TAILED DEER FOLLOWING DRUG RESTRAINT. J. A. Messon, III\*, P. F. Scanlon, and R. L. Kirkpatrick. Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061 and R. L. Butcher\*, West Virginia University, Morgantown, WV

Forty-one captive white-tailed deer (*Odocoileus virginianus*) were bled repetitively 4 times in association with a restraint-facilitating drug treatment or during physical restraint. Drug treatment were Succinylcholine chloride (SCC), RO-5-3448 (Ro-Hoffman-LaRoche) and a combination of Phenylhydrazine hydrochloride and Promazine hydrochloride (PH+P). Fifteen wild deer were bled at immobilization and at 30 minutes after injection with SCC. Progesterins were determined by competitive protein binding (CPB) assay for all bleedings. Progesterone and estrone were determined by radioimmunoassay (RIA) in wild deer. Progesterins increased significantly ( $P < 0.05$ ) following SCC-treatment in captive and wild deer. Progesterone and estrone increased significantly ( $P < 0.05$ ) in wild deer. Significant ( $P < 0.05$ ) changes in progesterins were not associated with any other treatment; however, progesterins did change in apparent association with adrenocortical changes. Changes in progesterins and estrone were thought to be secreted by the adrenal and appeared directly related to the varying stress caused by different restraint methods.

Bio 64

INFLUENCE OF PHYSICAL RESTRAINT AND RESTRAINT-FACILITATING DRUGS ON ANDROGEN LEVELS IN MALE WHITE-TAILED DEER. J. A. Messon III\*, P. F. Scanlon, and R. L. Kirkpatrick. Dept. Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Fifty-eight captive white-tailed deer (*Odocoileus virginianus*) were bled repetitively 4 times during 90 or 150 minute periods following treatments with a restraint facilitating drug or while physically restrained. Drug treatments were succinylcholine chloride (SCC), RO-5-3448 (RO, Hoffman-LaRoche) and a combination of Phenylhydrazine hydrochloride and promazine hydrochloride (PH+P). Fifteen wild white-tailed deer were bled at immobilization and 30 minutes following the injection of SCC. Male androgen values were determined by a competitive protein binding assay. Androgen values varied erratically in individual deer during the duration of the sampling periods. Significant ( $P < 0.05$ ) changes in androgens were not associated with any drug or manual restraint treatment. Results seemed indicative of inherent, pulsative release of androgens similar to that noted in cattle, sheep, and humans. This probably militated against the ability to detect differences due to treatment. Supported in part by McIntire-Stennis Project No. 636201.

Bio 65

NUTRITIONAL VALUES OF DIFFERENT PHOTOSYNTHETIC PATHWAYS: A CAUSE OF THE PLEISTOCENE EXTINCTIONS? J. W. Wilson, III, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

An extinction model for large Late Pleistocene herbivores is proposed based on the following factors. 1) Rapid climatic change from the more equable Pleistocene climatic regime to hot, dry summers and more severe winters. 2) This causes a concomitant increase in the dominance of  $C_4$  grasses over  $C_3$  grasses. 3) The  $C_4$  grasses are less nutritious and inhibit the reproduction of large herbivores which exploit the habitat in a fine-grained manner. Small herbivores, exploiting the habitat in a coarse-grained manner and capable of acquiring supplemental protein, can survive the floral change. 4) Extinction is a result of the change in the pattern of food resources.

Bio 66

THE SEASONAL DISTRIBUTION OF THREE MINNOWS (CYPRINIDAE) IN A PIEDMONT SECTION OF THE JAMES RIVER, VIRGINIA. W. S. Woolcott and E. G. Maurakis\*. Univ. of Richmond, Va. 23173

An investigation was made of the seasonal nearshore distributions of three species of minnows (Cyprinidae), *Notropis analostanus*, *N. ardens* and *N. hudsonius* collected in an 8 km stretch of a Piedmont section of the James River near Brems Bluff, Virginia. Fishes were collected by electrofishing from a boat within and outside a heated effluent created by a power station from July, 1973 to June, 1974. Abundance and percent occurrence data were used to analyze the seasonal distributions at nearshore areas for each species. *Notropis analostanus* was equally abundant at ambient and elevated temperature locations throughout the year except in the heated plume when temperatures exceeded 30°C during the summer. The greatest abundance of *N. ardens* occurred at ambient temperature nearshore areas from early fall to spring. In the heated plume, maximum numbers were recorded in late fall. *Notropis hudsonius* was most abundant at ambient temperature areas from the summer through the fall and avoided the plume area in the summer and early fall when temperatures exceeded 30°C.

Bio 67

ULTRASTRUCTURE OF MYXOID CHONDROSARCOMA WITH MYXOVIRUS-LIKE TUBULES POSSIBLY ETIOLOGICALLY RELATED TO THE DISEASE. S. H. Vernick\*, S. Kay\*, J. Morrison\*, and D. Cowan\*, Department of Pathology, Eastern Virginia Medical School, Norfolk, VA 23501 and Medical College of Virginia, Richmond, VA 23219.

Myxoid chondrosarcoma is a rather rare soft tissue tumor sometimes mistakenly diagnosed as a chordoid sarcoma. In the present study ultrastructural analysis confirmed the diagnosis as myxoid chondrosarcoma.

Characteristics of the tumor cells included bizarre pleomorphic nuclei, large numbers of mitochondria and dilated rough ER containing parallel arrays of tubules. These tubules which measured approximately 200 Å in diameter presented a helical periodicity characteristic of myxovirus-like bodies. While myxovirus-like bodies have been seen in other tumors including Burkitt's lymphoma, and osteogenic sarcoma, this is the first reported occurrence in myxoid chondrosarcoma. Relationship of the bodies to the etiology of the disease is as yet unconfirmed.

Bio 68

# Section of Botany

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

A DESCRIPTION OF VEGETATION ON THE SOUTH SLOPES OF PETERS MOUNTAIN. H. S. Adams, D. S. Lancaster Cmty. Col., Clifton Forge, Va. 24422, and R. W. Rhoades, Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Vegetation on open, south-facing slopes of Peters Mountain was sampled along 16 transects. Each transect was placed perpendicular to the contour of the slope and plots were established at intervals of 30.5 m elevation along each transect. *Quercus prinus* was dominant among overstory trees with *Q. rubra*, *Q. alba*, and *Q. coccinea* of lesser importance. Important species of the understorey were *Acer rubrum*, *Nyssa sylvatica*, and *Oxydendrum arboreum*.

Three community types were distinguished along the gradient of elevation. These communities reflected primarily the individualistic distributions of dominant oaks with elevation. *Q. rubra* and *Q. alba* dominated the community at elevations above 1158 m. High cover and diversity of herbs were characteristic of this community. At elevations between 792 and 1158 m, the vegetation was dominated by *Q. prinus* although other species of oak were important at scattered locations. Highest density and diversity of shrubs were displayed in this community. Below 792 m, the vegetation was composed of *Q. coccinea*, *Q. prinus*, and *A. rubrum*. Here, the highest index of diversity of overstory trees was recorded.

In general, the composition of vegetation did not differ markedly from descriptions of other workers for south slopes of the Appalachian and Blue Ridge Mountains.

EFFECT OF DESSICATION ON GERMINATION OF STRATIFIED LOBLOLLY PINE SEEDS. R. E. Adams, and P. P. Feret\*. Dept. Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Total laboratory germination of stratified loblolly pine seeds that had been subjected to from one to five 48-hour cycles of dessication (to less than 14 percent moisture content) and reimplantation (to approximately 40 percent moisture content) was not significantly different from stratified controls that had never been dried. Apparently seeds of this species, as well as Douglas-fir, ponderosa and white pine, can withstand dry conditions following stratification and during early germination. Thus, short periods of dry weather during these stages are not likely to cause failures in seedling production.

UNUSUAL FUNGAL AND HERBACEOUS PLANT ROOT ASSOCIATIONS FROM ARCTIC COASTAL TUNDRA. R. K. Antibus, A. E. Linkins, and O. K. Miller. Dept. of Biology, V.P.I. & S.U., Blacksburg, VA. 24061

Studies were undertaken in an attempt to characterize the relationship established between fungi and the roots and rhizomes of *Carex aquatilis* and other herbaceous plants of Arctic coastal tundra. Studies with light and scanning electron microscopy indicate that young fast growing rhizomes are free of fungal hyphae, while older rhizomes are only superficially invaded by hyphae. Smaller feeder roots may be covered by dark runner hyphae and may contain hyphae in their cortical cells. The invaded and non-invaded roots and rhizomes were found to differ in extractable cellulase levels. They were also found to differ in respiratory quotients and respiratory rates.

DANSYLATION OF RIBOSOMAL PROTEINS FROM PINUS LAMBERTIANA. L. B. Barnett, T. S. Ko, and R. E. Adams. Depts of Biochemistry and Nutrition and Forestry and Forest Products, VPI & SU, Blacksburg, Va., 24061

Ribosomes from seeds of sugar pine, *Pinus lambertiana*, were dansylated (180 molecules of dansyl chloride per ribosome particle), derivatizing the protein and leaving the RNA unreacted. The dansylated ribosomes were more sensitive to pancreatic ribonuclease than normal ribosomes at 5 mM MgCl<sub>2</sub> and at 0.1 mM MgCl<sub>2</sub>. No difference was observed between the sedimentation patterns of normal ribosomes and dansylated ribosomes or between their dissociation and reassociation patterns.

These observations are consistent with a model that envisions ribosomal proteins associated with non-helical portions of ribosomal RNA and protecting these sites from ribonuclease attack.

Research supported by Hatch Grant No. 616161 and McIntire-Stennis Grant No. 636125.

PRESCRIBED SPRING BURNING AT BIG MEADOWS, SHENANDOAH NATIONAL PARK: EFFECTS ON PLANT COMMUNITY COMPOSITION. E. E. Saxter and W. D. Cocking. Department of Biology, Madison College, Harrisonburg, Va. 22801

Perennial herb and scrub stage plots of successional forest were stressed on April 17, 1975, by controlled burning. Vegetation cover data were collected prior and subsequent to treatment and compared to unburned control plots. A total of 58 taxonomic units were found in the grass-dominated perennial community and 22 were present in the *Rubus-Robinia* dominated scrub community. Changes in community cover included increaser species (eg. *Fragaria*, *Solidago*, *Achillea*, *Potentilla* and *Rubus*) and others which were reduced in importance in response to the burning (eg. *Dennstaedtia*, *Polytrichum*, *Lycopodium*, and *Robinia*). Grass cover increased following fire in the scrub stage plots, but was unchanged in the perennial herb community. (Aided by National Park Service Research Grant, Mid-Atlantic Region)

CLIMPSSES OF VIRGINIA BOTANY, 1700-1850. Ronald Berkeley, Charlottesville, Va. 22901

The bicentennial year seems an appropriate time for Virginia botanists to pause in their researches to review the history of their science in the Old Dominion, and to honor those who have made distinguished contributions to it in times past. This paper will briefly trace the early history of Virginia botany, with particular emphasis on the eighteenth and early nineteenth centuries.

RECENT COLLECTIONS OF UNUSUAL SPECIES IN THE FLORA OF NORTHERN VIRGINIA, PARTICULARLY FROM FAIRFAX COUNTY. T.R. Bradley, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030

Collections over the last five years in Fairfax County and other counties in northern Virginia have produced numerous state and county records. *Akebia quinata* (Houttuyn) Decne., an escaping vine, is the first reported species in the Virginia flora in the family Lardizabaceae. Also reported new to the state are *Cacalia suaveolens* L. (Asteraceae), *Ilex crenata* Thunberg (Aquifoliaceae), *Leucospora multifida* (Michaux) Nuttall (Sclerophyllaceae), *Ligustrum japonicum* Thunberg and *Ligustrum ovalifolium* Hassk. (Oleaceae), *Napaea dioica* L. (Malvaceae) and *Ranunculus ficaria* L. (Ranunculaceae).

MICROSPORANGIAL MORPHOLOGY AND POLLEN DEVELOPMENT IN *CONOPHOLIS AMERICANA*. M.G. Burch\* and P.J. Hensher. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Microsporogenesis was studied in *Conopholis americana* (L.) Walther from specimens collected at Seashore State Park, Virginia Beach, Va. An epidermal layer was observed overlying an endothelial layer, the latter showing little or no fibrous thickenings on the inner tangential or anticlinal walls. This is characteristic of members of the Orobanchaceae. The inner surfaces of most endothelial and middle layer cells showed "small granular markings". The middle layer toward the interior of the anther is bi- or multi-seriate and elsewhere uniseriate. The tapetal layer is uniseriate, the innermost cells usually larger than other tapetal cells and all types are either uni- or bi-nucleate. Meiosis appears normal with simultaneous wall formation occurring by apparent furrowing producing a tetrad of microspores in decussate orientation. Pollen maturation appears to be slightly acropetal. The tapetum is of the secretory type, becoming somewhat vacuolate by the end of meiosis. Tapetal cells show little nuclear degeneration and are not absorbed by the time the microspores have separated.

With the exception of the absence of fibrous thickening in the endothecium and lack of nuclear degeneration and absorption of the tapetal layer, by the time microspores have separated, *C. americana* is typical of most dicots in microsporangial morphology and pollen development.

The Effect of Light on the Growth of Seedlings of Albino Tobacco in Tissue Culture. M. Byrd and E. Wilson, Dept. of Life Sciences, Va. State College, Petersburg, Va. 23803.

In order to design a simple experiment to be performed in an undergraduate plant physiology lab to show that the morphogenic effects of light on angiosperms are not mediated by chlorophyll, albino tobacco seeds were germinated sterily in petri dishes. Since the albino trait is recessive preliminary screening was done on light grown seedlings by transferring albinos to sterile media in test tubes. Height growth was to be measured after a period of three - four weeks. Simpler experimental designs are described to accomplish the same purpose.

VARIATION IN QUERCUS MAST PRODUCTION. K. Connor\*, P. P. Feret\*, and K. E. Adams. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

A comprehensive survey of existing literature shows that great variation in acorn production exists not only between isolated stands of oaks but also between individual trees within the stands. Three trees of the species *Quercus alba* L. of the *Leucobalanus* subgenus were studied in an attempt to correlate male and female flower production with acorn yield; artificial pollination experiments were also conducted. The data revealed that using flower production as an indicator of final acorn crop could lead to erroneous predictions. The results of this study indicate that certain basic areas of study need to be explored before predictive models of acorn productivity can be developed.



DEGRADATION OF  $^{14}\text{C}$ -LIGNINS BY SOIL MICROORGANISMS.

Don L. Crawford, Dept. of Biology, George Mason University, Fairfax, Va. 22030

The rate of decomposition of  $^{14}\text{C}$ -labeled lignocelluloses by natural soil and water microflora were studied. Natural lignocelluloses from red maple and white oak were labeled with  $^{14}\text{C}$  only in their lignin components by feeding plants  $^{14}\text{C}$ -phenylalanine through their cut stems.  $^{14}\text{C}$ -lignin decomposition rates were determined in numerous soil and water samples by monitoring  $^{14}\text{CO}_2$  evolved from the lignins as a result of microbial respiratory activity. Lignin decomposition was slow in all samples. Similar patterns of  $^{14}\text{CO}_2$  evolution were observed for both lignin types in both soil and water. Long lag periods of little  $^{14}\text{CO}_2$  evolution were followed by increasing rates until a maximal linear rate was reached. Individual samples, however, varied greatly in their overall rates of decomposition of the labeled lignins. The implications of these results on isolation techniques for lignin degrading microorganisms are discussed.

## FOUR PLANT COMMUNITY TYPES IN THE GREAT DISMAL SWAMP:

ABOVEGROUND BIOMASS AND LITTER. Claire V. Dabell, Dave Sampson\*, Frank P. Day, Jr., Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Four plant communities in the Great Dismal Swamp were sampled and estimates of density, basal area, aboveground standing crop biomass, and litter biomass were calculated. Aboveground biomass estimates for the community types were: Atlantic white cedar-229,800 kg/ha, cypress-344,500 kg/ha, maple-gum-195,700 kg/ha, and mixed hardwood-187,700 kg/ha. Litter estimates of woody stems < 2 cm thick and leaves for each community were: Atlantic white cedar-3,641.15 kg/ha, cypress-2994.2 kg/ha, maple-gum-1722.45 kg/ha and mixed hardwood-2930.25 kg/ha.

ECOSYSTEM STUDIES IN THE GREAT DISMAL SWAMP: A PRELIMINARY REPORT. F. P. Day, Jr. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

Studies are currently being conducted to gather data which will characterize the swamp ecosystem and to determine functional controls on swamp dynamics. A major difficulty is the heterogeneous nature of the swamp—varied depths of peat, varied history of human manipulation, varied vegetation types, and seasonal flooding. Four major community types are being studied—an infrequently flooded mixed oak stand, an Atlantic white cedar stand, a red maple-gum stand, and a cypress stand. A hypothesis being proposed is that a major control in the swamp is the regulation and inhibition of decomposition processes by flooding and pH. Decomposition has great significance in nutrient turnover and thus may regulate the swamp vegetation.

TEACHING MINERAL NUTRITION USING ALGAE. R. D. Decker.

Dept. of Biology, University of Richmond, Va. 23173

The traditional method to conduct mineral nutrition experiments in plant physiology courses is to use such crop plants as corn and beans. Using sand cultures or hydroponics characteristic deficiency symptoms usually develop. This system works satisfactorily and relates well with agriculturally oriented students. Non agriculture oriented students often do not relate to crop plants but do relate more to algae in terms of "pollution". Algal cultures grown in standard Hoagland's solution do not develop obvious deficiency symptoms but do show direct correlations of growth rates to nutrient supply. Varying the replacement level of a deficient nutrient (all other nutrients not limiting) results in growth rates which can be measured spectrophotometrically. Experimental design opportunities are increased over the more traditional methods of nutrition experimentation within the confines of a plant physiology course.

UPLAND HARDWOOD FORESTS OF THE CENTRAL COASTAL PLAIN OF VIRGINIA. Fidge DeWitt and Stewart Ware. Dept. of Biology, College of William and Mary, Williamsburg, Virginia 23185

Upland hardwood stands (27) free of recent disturbance were sampled by Bitterlich or point-centered quarter methods, and arranged in a Bray-Curtis type ordination. White oak ranked first in 11 stands and second in 9 others. Beech ranked first in 11 and second in 3 stands. Southern red oak ranked first in 3 and second in 1 stand, and tuliptree ranked first in two and second in three stands. The ordination revealed a three-cornered constellation of stands with southern red oak and sand hickory (*Parva pallida*) at one corner; white oak (and red maple) in another corner; and tuliptree and pignut and mockernut hickories concentrated in the third corner. Beech fell between the white oak and tuliptree areas, broadly overlapping both. Sweetgum fell between the tuliptree and southern red oak areas, overlapping greatly the former. In general the structural relationship of these forests is with the Southern Mixed Hardwood Forest (SMHF) of the southeast rather than with the oak-hickory forests of the Piedmont. Tuliptree is more important than in the SMHF, and hickories are less important. Red maple was more frequently encountered than in the SMHF, but was only occasionally important structurally. No correlation was found between forest structure and soil fertility or direction or degree of slope.

THE VASCULAR FLORA OF THE KENT BRANCH DRAINAGE SYSTEM, FLUVANNA COUNTY VIRGINIA. George M. Diggs, Jr.\*Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The study of this piedmont locality began in the spring of 1975 and is presently continuing, (as of April 1976). The area studied includes approximately fourteen square miles of northeastern Fluvanna County.

Several interesting distributional records, a number of rare species, and a sizeable group of county records were obtained. The distributional records include a number of species confined mainly to either the mountains or the coastal plain.

Unusual communities in the study area include an extensive swamp apparently resulting from the drainage of an old mill pond and a pine barren with a number of species uncommon to the Virginia piedmont.

Some taxa of interest include *Aira caryophyllae* L., *Aristida lanosa* Muhl. ex Ell., *Aristida longesepida* Polret, *Muhlenbergia sylvatica* (Torrey) Torrey ex Gray, and *Polygonum setaceum* Baldwin ex Ell.

COMPARISON OF SUPEROXIDE DISMUTASE LEVELS IN COTTON LEAF EXTRACTS FROM PLANTS GROWN IN NORMAL AND ELEVATED CONCENTRATIONS OF  $O_2$ . Joyce G. Foster\* and John L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In order to understand how plants deal with oxygen in their environment, we are studying superoxide dismutase which catalyzes the reaction:  $O_2^- + O_2^- + 2H^+ \rightarrow H_2O_2 + O_2$ . Other workers have reported elevated levels of this enzyme in several eucaryotic organisms grown under elevated  $O_2$ .

Cotton plants, *Gossypium herbaceum* 1697, were grown at 28-30°C under high light intensities and normal atmospheric conditions or atmospheres enriched to 35%  $O_2$ . Soluble protein extracts from leaf tissue, after heat treatment at 70°C for 5 minutes at pH 6.0, exhibited four major bands of superoxide dismutase activity having relative mobilities of 0.36, 0.53, 0.68, and 0.98 on 7% polyacrylamide gels electrophoresed at pH 8.9. Only the band having a mobility of 0.53 was insensitive to  $10^{-3}$  M  $CN^-$ , a property of the mitochondrial form of the enzyme in other organisms. These forms of superoxide dismutase remained qualitatively similar after exposure of the plants for 1 and 2 weeks to elevated  $O_2$ ; however, increased total amounts of enzyme present in the leaves were observed:

activity	control	1 week	2 weeks
units/mg protein	28	36	46
units/g tissue	19	25	74

(Supported by CSRS Grant 316-15-93.)

GERMINATION AND ANATOMY STUDIES OF PHORADENDRON SEROTINUM. Chauncy E. Harris\*, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Phoradendron serotinum (Raf.) M. C. Johnston is the common mistletoe of the southern United States parasitizing the trunks and branches of deciduous trees. The flowers are 2-3 mm in diameter and are borne on interrupted spikes. The white globose fruit is 6-8 mm in length and contains one seed. The endosperm of the seed contains an unusually high amount of chlorophyll which may assist in respiration and photosynthesis during germination. During the first year of growth elongation of the axis occurs in the radicle but not in the hypocotyl. In germination studies the radicle showed neither positive nor negative photo or geotropism. In young specimens almost all of the shoot growth originated from buds on the haustorial connection and not the hypocotyl. Host penetration and floral anatomy during and following fertilization are also presented.

FORESTS OF SMALL STREAM BOTTOMS IN THE PENINSULA OF VIRGINIA. Susan Glascock\* and Stewart Ware. Dept. of Biology, Coll. of William and Mary, Williamsburg, Va. 23185.

A forest community small in extent but frequently encountered in the Coastal Plain is the bottomland forest of small streams. These long, narrow, flat areas with twisting and often braided streams are bounded by (usually sharply rising) slopes with a strikingly different forest type. Seventeen fairly mature small stream bottom forests were sampled by the Bitterlich method, and arranged in a Bray-Curtis type ordination. Most stands were dominated by red maple, ash (mostly *Fraxinus pennsylvanica*) and American elm in some combination. These fell in the upper right portion of the ordination constellation, along with 2 stands dominated by baldcypress. Stands with a high importance of American hornbeam fell in the lower middle portion of the ordination, and willow oak (and water oak) occupied the left side of the ordination. Sweetgum and tulip tree occurred throughout, but were less important in the wettest sites. Swamp trees like tupelo gum, water hickory, swamp cottonwood, silver maple and box elder were absent from these sampled stands, though the first three do occur in some Peninsula swamps. Four other species often regarded as bottomland trees elsewhere in the Atlantic Coastal Plain (loblolly pine, beech, hackberry, and sweetbay) were of low structural importance and are more abundant in uplands in this area.

EVIDENCE FOR THE PRESENCE OF CYCLIC 3'5' ADENOSINE MONOPHOSPHATE (cAMP) IN YOUNG PEA ROOTS. G.M. Hilton\* and K.K. Nesius. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Pea roots were dissected into tips, root bodies (area between tip and embryo) and embryos and subsequently assayed for cAMP at 24 hour intervals over a period of four days. Concentrations of the nucleotide increased with time in tips and root bodies. The highest concentration was 20.1 picomoles/mg protein which occurred in 96 hour tips. Ninety-six hour root bodies achieved a concentration of 8.6 pm/mg. Concentrations of cAMP in the embryo remained constant between 1 and 2 pm/mg.

INCREASED LEVELS OF CYCLIC 3'5' ADENOSINE MONOPHOSPHATE (cAMP) IN YOUNG PEA ROOTS IN RESPONSE TO AUXIN TREATMENT. G. M. Hilton and K. K. Nesius, Dept. of Biological Sciences, Old Dominion University, Norfolk, Virginia 23508.

Pea roots were dissected and incubated for various lengths of time in  $3 \times 10^{-6}$  M indole acetic acid (IAA). Tips incubated for 2 hours showed a 10 fold increase in cAMP over water controls. After four hours, cAMP levels in water and IAA incubated tips were comparable. Root bodies incubated in IAA showed a twofold increase in cAMP after 2 hours and a fourfold increase after four hours. Concentrations of cAMP in embryos remained low, but increased slightly with IAA treatment.

COMPARATIVE IN VITRO SENSITIVITY OF AGGRESSIVE AND NON-AGGRESSIVE ISOLATES OF CERATOCYSTIS ULMI TO METHYL 2-BENZIMIDAZOLE CARBAMATE. D. B. Janutolo and R. J. Stipes, Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061.

Aggressive (A) and non-aggressive (NA) isolates of *Ceratocystis ulmi* (Buis.) C. Moreau from the USA (Iowa), England and the Netherlands, were tested for sensitivity to methyl 2-benzimidazole carbamate (MBC), MBC-H<sub>2</sub>PO<sub>4</sub> and MBC-HCl. After placement of 13 mm bioassay disks containing 100 µl of a 10 µg/ml solution of each compound on glucose-yeast extract agar (GYEA) plates surface-seeded with spores of one of the six isolates, plates were stored at 4°C for 24 h and then incubated for 48 h at 25°C. Zones of inhibition (ZOI) were recorded. The experiment was repeated twice with 10 replicates per isolate per chemical.

The ZOI of the Dutch NA isolate were significantly larger than that of the Dutch A isolate. ZOI of the English isolates were not significantly different, and those of the Iowa isolate were not consistent. The ZOI of the NA isolates were clear in contrast to the hazy ZOI of the A isolates eventually overgrown by the fungus. We conclude that the A isolates exhibit a more tolerant reaction to the fungitoxicants than the NA isolates.

## VEGETATION OF THE PEAKS OF OTTER AREA OF THE BLUE RIDGE.

Glenn G. Johnson and Stewart Ware. Dept. of Biology, Coll. of William and Mary, Williamsburg, Virginia 23185

Twenty-five old growth forest stands in the Peaks of Otter area were sampled by the Bitterlich method. Most combinations of altitude range, direction of exposure and topographic form were sampled or examined visually in order to establish a total vegetational pattern. Outside ravines a linear vegetational gradient from sharp ridges to high north slopes was discovered, with these subtypes: pine-chestnut oak; chestnut oak; chestnut oak-hickory; red oak-hickory; red oak-sweet birch; and yellow birch. Chestnut oak was more important at lower elevations, decreasing upward; red oak was more important at upper elevations, decreasing downward; the relative amounts varied in response to mesicness, red oak being more important in cooler and moister sites. Hickory (*Carva ovalis*) was important, even outnumbering oak, in good sites at all but the higher elevations (>3500 ft); there sweet birch was often an important associate of red oak. In ravines the vegetational gradient correlated with soil fertility instead of altitude or direction of exposure. Beech, hemlock, red maple, and sweet birch occurred mostly in ravines of lower fertility. Black cherry, bitternut hickory, basswood, sugar maple and red oak were most important where fertility was high. Tuliptree and yellow birch showed no correlation with fertility. The Peaks of Otter area is unusual for the Blue Ridge in having so little white oak and so much hickory.

## VERONICA (ASTRACAEAE) IN VIRGINIA: VERONICA AND ELEPHANTOPUS. Miles P. Johnson, Department of Biology, Virginia Commonwealth University, Richmond, VA 23284.

Three species of *Veronica* occur in Virginia. The distribution of *Veronica noveboracensis* and *V. glauca* is general through the state; *V. glauca* shows an apparent disjunct distribution. A putative hybrid between *V. noveboracensis* and *V. glauca* is reported from Virginia. *Elephantopus* consists of four species in Virginia. *Elephantopus nudatus* is a Coastal Plain species; *E. tomentosus* is present in the Coastal Plain and the Piedmont; *E. carolinianus* is general throughout the state. *Elephantopus elatus* is reported new to the Virginia flora.

## THE FLORA OF CHEATHAM ANNEX, YORK COUNTY, VA.

L. K. Kirkman. Dept. of Biology, Coll. of William and Mary, Williamsburg, Va. 23186.

The area studied was Cheatham Annex Naval Supply Center in York County, on the Peninsula of Va. This area, approximately 2,804.5 acres, is situated along the York River and is bisected by the Yorktown Colonial National Monument Parkway. Major types of habitat are 1) brackish marsh 2) fresh water swamps 3) pond margins 4) pine woods 5) mixed pine deciduous woods 6) mature beech, oak woods 7) roadside, trail and other disturbed areas.

The study began in March 1975 and will be continued through the summer 1976. As of April 1976, a total of 454 taxa, representing 278 genera of 94 families has been recorded. Of these species, 127 are potential county records, 17 are possible Peninsula records, and one has not been recorded for the state of Virginia. Some interesting collections include *Desmanthus illinoensis*, *Tridens strictus*, *Paspalum urvillei*, *Gallium parisiense*, *Panicum quinquefolium*, *Cassia obtusifolia* and *Cyperus brevifolius*.

## THE CULTURE OF PEA ROOT CORTICAL TISSUES AND PROTOPLASTS.

C. E. Landgren. Dept. of Biology, George Mason Univ., 4400 University Dr., Fairfax, Va. 22030

Naked protoplasts of root cortical cells were isolated from varieties of *Pisum sativum* using commercially available cell wall degrading enzymes. Culture conditions suitable for cell wall regeneration and mitosis were established. DNA levels in mitotically active populations were observed. DNA synthesis was followed using <sup>3</sup>H-labeled thymidine. Temperature, pH, auxin and cytokinin optima were determined using cell counting techniques to follow the accumulation of mitotically produced cell colonies. The effects of carbohydrates as osmotic agents and as carbon sources were observed.

Severe chromosome damage and spindle dysfunction were observed in a significant portion of the cell population. These damages seemed to prevent mitotic after the first round in which the damaged cell was involved.

## HIGHER FUNGI ASSOCIATED WITH MARITIME TUNDRA TOPOENVIRONMENTS OF AMCHITKA AND ADAK ISLANDS. G.A. Laursen, Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061

Fruiting body collections of 163 high fungi, ascomycetes and basidiomycetes, were made and their ecological associations noted during a 1975 field study on Adak and Amchitka Islands, Alaska. The fungi represent 17 families and 33 genera of basidiomycetes, 4 families and 5 genera of ascomycetes and 1 mycozyete. Most of these collections represent new records for the Aleutian Islands, where few mycological investigations have been made. Collections were made from three ecological topoenvironments, the dry and well drained Uplands, the wet and poorly drained Lowlands, and the Beach. Most fungi were categorically saprobic decomposers of organic litter. One true mycorrhizal species of *Rhizoglyphus* and two suspected mycorrhizal species, *Clavulinopsis* and *Hygrophorus*, were found. The genera composite represented a late spring and early summer temperate latitude basidiomycete flora. The maritime tundra mycoflora encountered was distinct from, and showed very little similarity to, arctic tundra mycoflora encountered near Barrow, Alaska. (Aided by DBER ERDA Grant E-(40-1)-4990.)

MEASUREMENT OF TRANSPIRATION IN *Pinus taeda* L. AND *Liquidambar styraciflua* L. IN A CLOSED ENVIRONMENT GROWTH CHAMBER USING TRITIATED WATER. G.F. Levy, D. E. Sonenshine, J.K. Czoch. Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508.

Transpiration rates of loblolly pine (*Pinus taeda* L.) and sweetgum (*Liquidambar styraciflua* L.) were measured at two different water vapor pressure deficits (V.P.D.) in a controlled environment growth chamber using tritiated water as a tracer. The trees were maintained in a sealed plant bed containing a hydroponic nutrient solution. Samples of leaves, chamber air, spiked nutrient and control solutions were assayed for activity using liquid scintillation techniques. The transpiration rate of sweetgum (4.95 ml/hr/gm) was found to be 5 times greater than that of loblolly pine (1.03 ml/hr/gm) at the lower V.P.D. and 8 times greater at the higher V.P.D. (15.99 ml/hr/gm for sweetgum vs. 2.19 ml/hr/gm for pine). Transpiration in both species rose with increasing vapor pressure deficit although sweetgum increased its output by 3 times while pine only doubled its rate. Cyclical changes in transpiration rates were noted in both species; the sweetgum cycle peaked at 6 hour intervals and the pine cycle at 9 hour intervals.

**PRESCRIBED SPRING BURNING AT BIG MEADOWS, SHENANDOAH NATIONAL PARK: EFFECTS ON COMMUNITY PRODUCTIVITY.**

S. L. Lilly and W. D. Cocking, Department of Biology, Madison College, Harrisonburg, Va. 22801

The standing crop of plant biomass was monitored throughout the growing season in the plots described in the preceding paper. Changes in living and dead tissue components of grass, forb and non-flowering compartments were determined. A maximum 73% reduction in living herb community biomass occurred one month following the burn treatment while a maximum 53% reduction in the total *Rubus-Robinia* scrub vegetation was delayed two additional weeks. The maximum reduction in living tissue due to the stress did not persist in either community and significant repair occurred in both by the end of the growing season. There was less than 15% reduction in each by late August when the control standing crops were 4113 g dry wt/m<sup>2</sup> and 8585 g dry wt/m<sup>2</sup> in the perennial herb and *Rubus-Robinia* scrub communities respectively. (Aided by National Park Service Research Grant, Mid-Atlantic Region)

**CONCEPTS OF THE GENUS PLEUROTUS.** Don L. Manning. Dept. of Biology, V.P.I.S.S.U., Blacksburg, Va. 24061.

As with many other genera of hymenomycetes, the genus *Pleurotus* (Fr.) Quelet has undergone revision from time to time with the result that many of the species have been distributed to other genera. This tendency is the result of emphasizing the hyphal-approach system versus the gross morphology. Fries placed all gilled fungi under the genus *Agaricus* and then divided the various species into tribes, e.g., tribus *Pleurotus*. This tribe was subsequently given generic rank by Quelet. Saccardo in his *Sylloge Fungorum* listed over 100 species of *Pleurotus* but today this number has been reduced anywhere from 28-40 depending on the investigator. Two other genera which are very close to *Pleurotus* are *Panus* and *Lentinus*. These three genera can be separated from each other by using a combination of macroscopic and microscopic characters or by using the structure of the sterile tissues of the hymenophore. In respect to the latter method, the arrangement of the hyphae of the hymenophoral trama and the presence or absence of a subhymenium are emphasized.

**ALPINE FLORA OF NORTHERN ITALY.** *Lubow A. Margolena*, Res. Biologist Rtd. USDA Beltsville, Md.

Biology of Alpine flora is reviewed. The illustrations include ca. 60 species observed during summer vacations (1967, 69, 74, 75) in the Dolomites, the Bormio area and the Stelvio National Park, Italy. Elevations ranged from 300 - 3000 m.

**PHYTOPLANKTON COMPOSITION IN THE EASTERN COASTAL WATERS OF THE UNITED STATES.** H. G. Marshall, Dept. Biological Sciences Old Dominion Univ., Norfolk, Va. 23508.

The composition of the major phytoplankton groups are discussed in relation to their distribution in the coastal waters of eastern United States. There were 614 species identified in this study based on 22 cruises and collections at 542 stations. Greatest density and diversity of species occurred within 50 miles from shore, with the diatoms predominating in the neritic waters, decreasing seaward. Higher temperatures and salinities favored the Coccolithophores which increased in dominance seaward. Pyrrophyceans were common at all stations favoring salinities between 29 to 33 ‰ and temperatures 11 to 23°C. Characteristic cold water diatoms were *Thalassionema nitzschoides*, *Skeletonema costatum* and *Thalassiosira nordenskiöldi*. Although warm water dominants north and south of Cape Hatteras differed in some forms, there were numerous tropical species found in the Gulf of Maine. Ubiquitous species in these coastal waters were *Skeletonema costatum*, *Thalassionema nitzschoides* and the coccolithophore *Coccolithus huxleyi*. Additional comment was made on the large concentrations of *Melosira* species found in these waters. Both alive and apparently older non-living forms of this genus were found in abundance.

Supported in part by NSF grant GA 31768 and NASA Contract 5-21816.

**PEROXIDASE VARIATION IN QUERCUS.** J. S. Mayberry\*, P. P. Forêt\*, and R. E. Adams. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The developmental sequence of isoperoxidase enzymes in acorns and seedlings of *Quercus alba* was followed using polyacrylamide disc electrophoresis. Maturing acorns were collected from three sample trees at weekly intervals. When acorns had matured, seedlings were grown and sampled on a weekly basis. Seedling tissues assayed included root tips, hypocotyls, cotyledons, stem sections, and leaves. Results demonstrated both among tissue and among tree differences in peroxidase isoenzyme expression. The study provides basic information necessary for the development of sampling procedures to use for studies of *Quercus* isoenzyme genetics.

**GROWTH OF ACHLYA BISEXUALIS ON CELLULOSE AND OTHER POLYSACCHARIDES.** A.H. Miele\* and A.K. Linkins. Dept. of Biology, Virginia Polytechnic Institute and State Univ., Blacksburg, Va. 24061

The antheridial strain of the dioecious water mold *Achlya bisexualis* was grown vegetatively in shake culture in chemically defined media using glucose, cellulose, laminarin, soluble starch and alginic acid as carbon sources. Quantitative evaluation of growth and cellulase levels was conducted with media containing glucose and cellulose. Evaluation of cellulase by viscometric and generation of reducing sugar assays suggests that cellulase in culture to function in wall softening for tip growth and plays a significant role in degrading cellulose for uptake by *A. bisexualis*.

BETULA UBER, THE VIRGINIA ROUND-LEAF BIRCH, REDISCOVERED IN SOUTHWEST VIRGINIA.

Douglas W. Ogle, Dept. of Biology, Va. Highlands Cmty. Coll., Abingdon, Va. 24210 and P. M. Mazzeo, U.S. Nat. Arboretum, Washington, D.C. 20002

*Betula uber* (Ashe) Fernald, unknown as a living plant for over 60 years and thought to be extinct, has been rediscovered in Smyth County, Virginia. It is represented by one known population consisting of 12 mature trees, one sapling, and 21 seedlings. Details relative to its history, rediscovery, habit, habitat, and common name are given.

NOTES ON SOME OF VIRGINIA'S RARE PLANTS.

Douglas W. Ogle, Dept. of Biology, Virginia Highlands Community College, Abingdon, Va. 24210  
Distributions of the following Southwest Virginia plants are discussed and localities are given. *Kalmia carolina* Small, *Triphora trianthophora* (Sw.) Rydb., and *Desmodium canadense* (L.) DC.

GERMINATION AND SPOROPHYTE DEVELOPMENT OF DRYOPTERIS, PART I. J. Michael Fitchford\* Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23508

This project is the first part of a series of studies of Dismal Swamp *Dryopteris*. The purpose of this project was to determine the length of time from spore germination to sporophyte development for each species, and to note any differences in the morphology of the gametophytes. Spores of *D. celsa*, *D. cristata*, *D. intermedia*, *D. spinulosa* and *D. x separabilis*, were collected in the fall of 1975 and germinated on peat pellets in a controlled incubator. The temperature was maintained between 25°C and 30°C with the light on a twelve hour cycle. The length of time to sporophyte development differed from species to species with *D. celsa* being the shortest and *D. intermedia* the longest. The gametophytes of the diploid species (*D. intermedia*) were smaller than the tetraploids (*D. celsa*, *D. cristata*, *D. spinulosa*). (Aided by NSF grant EPO75-04303)

SOME INTERESTING TAXA FROM A FLORA OF HONE QUARRY, ROCKINGHAM COUNTY, VIRGINIA. Gerald F. Roe\*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

A floristic study of the Hone Quarry watershed was conducted from 1973 to 1975. Hone Quarry encompasses approximately 11 square miles of mountainous area in the George Washington National Forest in Virginia; the area is within Rockingham County. The points that will be emphasized include a description of the various habitats found there, county record data, a discussion of some of the uncommon and rare plant species occurring there, and mention of a plant record for Virginia, *Epipactis helleborine* (L.) Gratz. *Trillium pusillum* Michx. is reported for Rockingham County as a significant distributional plant record.

EVALUATION OF SPECTROPHOTOMETRIC METHODS FOR MEASURING GLYCOLATE OXIDASE ACTIVITY IN COTTON LEAF EXTRACTS. Phillip N. Russ\* and John L. Hess. Dept. of Biochemistry and Nutr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

As glycolate oxidase catalyzes the following reaction,  $\text{glycolate} + \text{O}_2 \rightarrow \text{glyoxylate} + \text{H}_2\text{O}_2$ , it may have a central role in photorespiration in green plants. This enzyme has been traditionally monitored by measuring  $\text{O}_2$  uptake or by the spectrophotometric determination of dichloroindophenol reduction under anaerobic conditions; these procedures are either insensitive or cumbersome. We evaluated the reaction in which  $\text{H}_2\text{O}_2$  formed during glycolate oxidation is coupled to oxidation of diaminobenzidine by the addition of horseradish peroxidase. The technique also provides opportunity to visualize glycolate oxidase on polyacrylamide gels following electrophoresis. Final concentrations in the assay were: 0.23 M phosphate buffer, pH 8.3; diaminobenzidine, 0.4 mg/ml; horseradish peroxidase, 66 µg/ml; and glycolate, 10 mM. Glycolate oxidase was isolated from cotton, var. Coker 310, and reaction rates monitored at 366 nm were determined to be linear with respect to time and enzyme concentration. The reaction required both glycolate and  $\text{O}_2$ . The  $K_m$  for glycolate was determined to be 0.87 mM. FEN addition did not enhance activity of the oxidase from cotton. In conclusion, we commend this assay to be a direct, convenient means for monitoring glycolate oxidase offering distinct advantages over other assay techniques. (Supported by CSRS Grant 316-15-93.)

SOME FOSSIL PLANTS FROM THE MISSISSIPPIAN OF SOUTHWESTERN VIRGINIA. J.E. Skog\* and P. G. Gensel\*, Dept. of Biology George Mason Univ., Fairfax, Va. 22030 and Botany Dept., Univ. of North Carolina, Chapel Hill, N. C. 27514

Recent collections in the Price Formation of Mississippian age in southwestern Virginia have yielded a diverse flora. Included in the flora are specimens of *Lepidodendropsis*, *Triphyllopteris*, *Rhodopteris*, *Cardiopteridium*, and a new foliage type referable to *Neuropteris*. Sporangial complexes have been found; one of them is shown to be attached to *Triphyllopteris* foliage. These sporangial masses are reminiscent of types found in the Devonian. Seeds have been found in association with *Triphyllopteris* also, some free and some in cupules. There were apparently at least two types of seed plants present in this flora. The plants found in this formation indicates a fairly diverse coal swamp flora.

THE EFFECTS OF SOIL MOISTURE ON TREE SEEDLINGS. D. W. Smith\*, E. B. Lewis\*, and R. E. Adams. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Potted seedlings of red maple (*Acer rubrum* L.), table-mountain pine (*Pinus pungens* Lamb.), pitch pine (*P. rigida* Mill.), Virginia pine (*P. virginiana* Mill.), and Scotch pine (*P. sylvestris* L.) were grown at 0, 25, 50, and 100 percent available soil moisture to evaluate their early survival and development under adverse soil moisture conditions.

After one growing season table-mountain pine produced more dry weight than the other species at the two low soil moisture treatments. Maximum growth occurred at 25 percent soil moisture. Red maple growth was limited by inadequate soil moisture at the 0 and 25 percent soil moisture levels; however, at 50 percent soil moisture level red maple produced more dry weight than the other species. Growth of pitch and Virginia pines increased with available soil moisture and was maximum at 100 percent soil moisture. Scotch pine dry weight growth increased to a maximum at 50 percent soil moisture.

(Supported by McIntire-Stennis Grant 636219-0)

CELLULOSE IN THE SPORES OF *Dictyostelium discoideum*. L. A. Stein\*, A. E. Linkins, and C. L. Rutherford, Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Studies were initiated on the purification and identification of the soluble and membrane bound forms of cellulase in the spores of *Dictyostelium discoideum*. Research to date has shown increased levels of the soluble enzyme present in the late spore stage. Through viscometric and reducing sugar assays the partially purified enzyme has been tentatively identified as a  $\beta$ 1, 4 endoglucanase, EC 3.2.1.4. Gel filtration and electrophoresis indicate a highly charged molecule with a molecular weight of around 100,000 daltons.

A Survey of the Vascular Flora Along the Appomattox River at the Fall Line in the City of Petersburg and in the Counties of Dinwiddie and Chesterfield. C. Thomas and B. Wilson. Dept. of Life Sciences, Va. State College, Petersburg, Va. 23803.

The survey was done at the request of the Appomattox scenic river committee. A four mile segment on both banks between Ettrick and Matocsa was chosen. Ten collection areas were selected on the basis of accessibility, property owner permission and quality of the vegetation. In these areas plants between the bank and elevation of 50 feet above sea level were sampled. Collections are being made biweekly from Feb. 1 to Nov. 1. Transects to determine the composition of the overstory vegetation will be made in each area. At the present time 63 families and 175 species of plants have been identified. The survey excludes grasses.

THE HISTORY OF BOTANY IN VIRGINIA DURING THE NINETEENTH AND TWENTIETH CENTURIES. Howard M. Smith. Dept. of Biology, Univ. of Richmond, Va. 23173

Given the interest in the Virginia flora in the colonial period, it is surprising that a state flora has yet to be produced. In the nineteenth century, Asa Gray at Howard and N. L. Britton at New York Botanical Garden wrote manuals for the northeastern states and nominally included Virginia in their range. However, neither explored Virginia to any great extent. Later both men encouraged associates to work in the southeast. These were A. W. Chapman and J. K. Small, but these men stopped the range of their works at North Carolina.

In the twentieth century, the botanical interest centered in Washington, D. C. and a flora of Virginia has still to be produced.

EFFECTS OF pH AND TEMPERATURE ON THE GROWTH OF TEN ENDOTHA SPECIES. R. J. Stipes and M. K. Roane, Dept. Plant Pathol. & Physiol., Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061.

As a part of our physiotoxicologic study for a monographic treatment of the world species of *Endothia*, we investigated the effects of medium pH and incubation temperature on the vegetative growth of the following species: *eugeniae* (E), *fluens* (F), *gyroza* (G), *havanensis* (H), *nitschkei* (N), *macrospora* (M), *parasitica* (P), *singularis* (S), *tropicellae* (T) and *viridistroma* (V). We used Campbell's medium (Trans. Brit. Mycol. Soc. 50:413-421) for pH and glucose-yeast extract (5 g + 1 g/l) broth for temperature assays. The temperature study included 17, 23, 28 and 32C, and 23C was used for the pH assay. Vegetative growth was measured after 14 d in the pH study and after 5, 10, 15 and 20 d in the temperature study.

All isolates grew poorly at pH 3 and more sparingly, if at all, at pH 7 and 8. The optimum pH for H, P, N & V was 4, for G, M & T was 5 and for S was 6; two E isolates had optima at 3 & 6, and two F isolates had optima at 4 & 6. All isolates grew at 17-32C. The following temperature optima were found: 17 for P, 17-28 for S, 17-32 for E, 23 for F & N, 23-28 for T, 23-32 for G, V & M and 32 for H.

Differences in pH and temperature optima among taxa and in species groupings for common optima throughout the ranges studied possibly may be used in conjunction with other taxonomic criteria to delimit taxa.

VEGETATIONAL ZONATION AND SUCCESSION WITHIN INTERDUNAL DEPRESSIONS ON THE BARRIER DUNE SYSTEM OF SOUTHEASTERN VIRGINIA. R.W. Tyndall\* and G.F. Levy. Dept. of Biological Sciences, Old Dominion Univ., Norfolk, Va. 23508

A series of circular-to-irregularly shaped interdunal depressions was recognized in the fall of 1974 between the fore- and rear dunes of the Back Bay National Wildlife Refuge and the False Cape State Park by means of aerial infrared photography. At least four plant communities form zones dominated respectively by 1) *Scirpus americanus*, *Eleocharis quadrangulata*, *E. parvula*, and *Hydrocotyle umbellata*; 2) *Spartina patens*; 3) *Myrica cerifera* and *Spartina patens*; and 4) *M. pensylvanica* and *Rhus radicans*. Zonation appears to be governed by the duration of maximum and minimum soil moisture and competition. Succession is primarily physiographic. Waterfowl activities inhibit succession in the sedge zone while feral hog uprooting induces regressive succession in the *Spartina patens* zone. Cyclic succession due to the shading effect of *Prunus serotina* occurs in the *M. pensylvanica* zone. *Quercus virginiana* appears to be the ultimate climax species.

AN INTENSIVE STUDY OF THE SPRING PHYTOPLANKTON BLOOM IN LYNNHAVEN BAY, VIRGINIA. Donald Lynn Webster, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 235078.

Phytoplankton samples were collected biweekly from two stations in Lynnhaven Bay, Virginia over the period January 24 to June 9, 1975. Water temperature, salinity, pH, oxygen, ammonia, urea, reactive nitrite, reactive nitrate, reactive phosphorus, productivity, transparency, and weather conditions were recorded concurrently. Data was manipulated employing analysis of variance, simple correlation, correlation matrices, and forward stepwise multiple regression. Total phytoplankton numbers exhibited a unimodal pattern. The spring bloom lasted from April through May. Phytoplankton growth was primarily a function of nutrient supply and temperature. Nutrient runoff following heavy spring rains appeared to stimulate pyrrhophycean growth. Changes in species composition occurred following these perturbations. Productivity exhibited a distinctive bimodal pattern and was primarily a function of light and temperature. Cryptophytes, cyanophytes, and xanthophytes were very important throughout this study. *Olisthodiscus* sp. and *Rhodomonas amphioxea* were dominant from January through March. *S. costatum* became dominant in April and remained so until dominance shifted to an unidentified phytoflagellate in late May. Both stations were similar in species composition and succession. Total phytoplankton counts were generally higher at Station II in the Eastern Branch, reaching  $3.8 \times 10^7$  numbers per liter on May 22.

VEGETATION OF THE CEDARS, LEE COUNTY, VIRGINIA.

E. Spencer Wise, Dept. of Biology, Christopher Newport Coll., Newport News, Va. 23606 and A. M. Harvill, Jr., Dept. of Biology, Longwood Coll., Farmville, Va. 23901

The Cedars is a limestone rock outcrop, with little to no soil covering, located west of Jonesville and covering an area of approximately 10 square miles. Dominant woody species is *Juniperus virginiana* and the area takes its name from the common name of this species. Other scattered woody species include *Ulmus alata*, *Rhus aromatica*, and *Robinia pseudacacia*. All these species are frequently associated with dry or infertile soils.

The vegetation includes species apparently found only in The Cedars in Virginia (example *Agave virginica*); one species found only in The Cedars in western Virginia but occurring as a rare species in southeastern Virginia (*Croton monothecygnus*); western species fairly widespread in western Virginia (example *Bouteloua curtipendula*); and species found in eastern Virginia, skipping the rest of the state, then coming up the Mississippi Valley to western Virginia (example *Campsis radicans*).

Several genera, including *Leavenworthia*, *Petalostemum*, and *Talinum* which are common in the cedar glades of Tennessee have apparently not migrated this far.

## Section of Chemistry

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

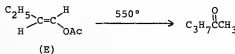
HIGH SPEED REVERSE PHASE LIQUID CHROMATOGRAPHY OF FREE FATTY ACIDS AND LIPID HYDROLYZATES. E. C. Adams and J. M. King. Dept. of Chemistry, Va. Commonwealth Univ., Richmond Va. 23284

The rapid separation of the higher free fatty acids in ten minutes time and without prior derivatization will be discussed. The experimental system consists of a hydrophobic-silylated silica bead column, 10 micron particle diameter, in conjunction with a ternary eluent composed of water, acetonitrile, and tetrahydrofuran. Retention data is reported for over twenty solutes, varying in chain length, degree of unsaturation, and substituent functional groups. Total separation can be achieved between solutes of a homologous series differing by two carbon numbers. Unsaturated fatty acids of the same carbon number are retained less due to their increased mutual solubility in the mobile phase.

Distinct profiles characteristic of the fatty acid composition of natural oils will be presented. These results indicate that the fatty acid profile is highly characteristic of the type and source of the oil. Chromatographic resolution is highly solvent dependent and the variation in the composition of this media has a pronounced effect on the separation of the constituent acids. Excellent quantitative results have been obtained, particularly when a UV detector is used in tandem with a RI monitor. The conditions employed in this chromatographic assay procedure are in general applicable to many fatty acid derivatives and can be used to separate linear fatty alcohols.

PYROLYSIS OF ENOL ESTERS. Robert C. Atkins, Donna S. Amenta, Dept. of Chemistry, Madison College, Harrisonburg, VA 22801

Several enol esters have been prepared, typically by reaction of the carbonyl compound with acetic anhydride. The pyrolysis of these esters will be described. For example, separation and pyrolysis of the individual isomers of 1-butenyl acetate showed the E isomer to undergo facile reaction, while the Z isomer was largely recovered unchanged. The mechanistic implications of this result will be discussed in relation to previous enol ester studies.



The pyrolysis of an enol lactone,  $\alpha$ -angelicalactone, to yield carbon monoxide and methyl vinyl ketone will also be described.

DEVELOPMENT OF A TECHNIQUE FOR THE ANALYSIS OF LOW CONCENTRATIONS OF HYDROGEN CHLORIDE IN MOIST AIR. R. R. Bailey, P. E. Field, and J. P. Wightman. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A microcoulometer was used to determine the applicability of  $\text{NaNO}_3$ -coated pyrex tubes for the analysis of low doses of HCl in moist air. No dependence of the technique on temperature, relative humidity or time was found. The analysis of 4.2 ppm HCl in moist air was made for dosing times between 10 and 90 sec. Analysis of coated tubes containing 189-850 ng chloride was demonstrated. The relative accuracy for the 189 ng chloride sample was 0.1 with a relative standard deviation of 3%. (Financial support for this work under NASA Contract NAS1-13175-1)

ADSORPTION OF HYDROGEN CHLORIDE AND WATER VAPOR ON ALPHA AND GAMMA ALUMINA. R. R. Bailey and J. P. Wightman. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The influence of outgas conditions and temperature on the adsorption of hydrogen chloride and water vapor on alpha and gamma alumina has been studied. Adsorption of water vapor was reversible but hydrogen chloride adsorption was found to be only partially reversible; an indication of chemisorption. A difference in the adsorption capacity of the two aluminas was exhibited for both water vapor and hydrogen chloride. Characterization of both aluminas was performed using X-ray powder diffraction, scanning electron microscopy (SEM), BET nitrogen surface area measurements and infrared spectroscopy. (Financial support for this work under NASA Grant NSG 1195.)

CHANGES IN TRACE ELEMENT CONCENTRATIONS AS A MEASURE OF TUMOR RESPONSE TO CHEMO- AND RADIOTHERAPY. M. D. Baker,\* W. Brookhart,\* and R. Allen,\* Department of Chemistry, University of Virginia, Charlottesville, Va. 22901.

The changes in the concentrations of a number of trace elements have been determined by neutron activation analysis in a solid tumor model (3924A Morris hepatoma), liver, and serum, following both 5-fluorouracil administration and radiation treatment. Studies have also been carried out for non-tumor bearing animals after 5-fluorouracil and radiation. The changes in some of the trace elements parallel destructive changes in the tumor. The potential clinical usefulness of these trace elements are being evaluated along with other biological markers which may eventually be utilized to assess the therapeutic effectiveness of different treatment modalities as well as monitor the patient for possible recurrence of the cancer following treatment. Studies are in progress to determine if changes in the urinary concentrations of these trace elements parallel the time sequence of the destructive changes found in the tumor.

ALUMINOHYDRIDE REDUCTIONS OF CYCLIC KETONES, I: REDUCTION OF 1,2-CYCLOHEXANEDIONE. R. E. Baker\* and T. B. Hill. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

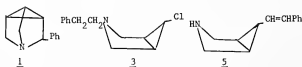
1,2-Cyclohexanedione was reduced with varying stoichiometric amounts of 1) lithium tetrahydroaluminate (LAH), 2) lithium trimethoxyhydroaluminate (LTMAH) and 3) lithium tri-*t*-butoxyhydroaluminate (LTBAH) in tetrahydrofuran at  $-78^\circ$ . The products, 2-hydroxycyclohexanone(II) and cis-trans-1,2 cyclohexanediol(III) were estimated by gas chromatography.

LTMAH reductions of (I) gave 85-95% of (II) and <5% of diols(III). LAH reductions gave predominantly (II) but significant amounts (25%) of diols(III) at high excesses of LAH. LTBAH reductions showed a reverse effect with the major product being diols(III, 60-80%) and less (<16%) hydroxyketone(II).

In cases where appreciable amounts of diols(III) were produced, the percent *cis*-isomer was 58 to 62%. These results contrast those of C. H. Snyder [J. Org. Chem., 61, 4220(1966)] who found that the percent *cis*-diol(II) varied with excess reducing agent in reductions of (I) with aluminum isopropoxide.

REARRANGEMENT FOLLOWING INTRAMOLECULAR CARBENE INSERTION OF 6-TRANS-STYRIL-3-AZABICYCLO [3.1.0] HEXANE. R. C. Bass and R. F. Boswell.\* Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

The formation of 3-phenyl-4-azabicyclo [2.2.1.0<sup>2,6</sup>] heptane (1) from 3-benzyl-6-exo-chloro-3 azabicyclo [3.1.0] hexane (2) by a proposed intramolecular carbene or carbenoid carbon hydrogen insertion has been reported [J. Org. Chem., 40, 2419 (1975)]. Using the reported procedure, 6-exo-chloro-3-phenyl-3 azabicyclo [3.1.0] hexane (3) was prepared by addition of phenethylamine to 1,1-dichloro-*cis*-2,3, bis-(chloromethyl) cyclopropane (4) followed by reduction with zinc dust in glacial acetic acid. Treatment of 3 with butyllithium gave a new substance characterized as 6-*trans*-styril-3-azabicyclo [3.1.0] hexane (5). It is postulated that carbenoid insertion produces an analogue of 1 which undergoes rearrangement to yield 5.



ALTERNATIVE INSTRUCTIONAL STRATEGIES FOR GENERAL CHEMISTRY. James D. Beck. Dept. of Chemistry, Virginia State College, Petersburg, Va. 23803

For several years we have been experimenting with non-traditional methods of instruction in one section of our General Chemistry course. During the past year we implemented an integrated approach in which we retained the traditional textbook-lecture-recitation components but added a variety of alternative instructional activities. These included computer-generated individualized problem sets, slide/tape programs, practice sessions, audio tapes, and interactive computer programs for drill and practice. Students were required to complete several of these activities but were allowed to choose from the various alternatives that were made available to them. We also used a study guide for the first time and distributed specific objectives for each unit of work. Over twenty simple computer-assisted-instruction programs have been written as part of this project.

The effect of this approach on student performance is difficult to assess as yet. Students did indicate that they liked having the alternatives made available to them and that most of the activities were helpful. Employment of the alternative instructional modes also enabled us to use more of the lecture time for motivational activities such as performing demonstrations and showing films. (Aided by funds obtained from the U.S. Dept. of Health, Education, and Welfare under the Title III program.)



THE REACTION OF PENTAFLUOROSULFUR BROMIDE WITH DIFLUOROETHYLENES. Alan Berry\*, George Mason University, Fairfax, Va. 22030 and W. B. Fox\*, Naval Research Laboratory, Washington, D.C. 20375.

The reaction of pentafluorosulfur bromide with *cis* and *trans* 1,2-difluoroethylene has yielded two isomeric products. These have been tentatively identified from nmr studies as the *erythro* and *threo* addition products. Dehydrohalogenation reactions have produced the *cis* and *trans* pentafluorosulfur-1,2-difluoroethylenes. The implication of these results on the possible mechanism of the reaction of  $\text{SF}_5\text{Br}$  with olefins will be discussed. (Work done at the Naval Research Laboratory).

ENZYME CATALYZED TRANSFORMATIONS OF STEROIDS. THE STEREO-CHEMISTRY OF THE REDUCTION OF A DOUBLE BOND WHICH CAUSES HORMONE ACTIVATION. A.L. Betts\*, and O.R. Rodig, Dept. of Chemistry, University of Virginia, Charlottesville, VA 22911.

Androgenic hormones, such as testosterone, are converted to more potent androgens in the prostate gland via the reduction of the  $\Delta^4$  bond. The stereochemistry of the reduction of  $\Delta^4$ -3-keto compounds has been previously studied; however a  $\Delta^4$ -3-keto intermediate may exist. The mechanism of the reduction of the  $\Delta^5$  bond has not been previously studied; in fact there are few examples of reductions of double bonds that are not conjugated to ketones in the steroid ring system. We therefore studied the yeast reduction of androst-5-ene-3,17-dione-6-d, which is known to proceed via  $\Delta^5$  reduction, since yeast will not reduce  $\Delta^4$ -3-keto compounds. The orientation of the deuterium was determined by comparing the NMR spectra of the reduction product with spectra of known deuterated samples using the lanthanide paramagnetic shift technique.

VOLUME CHANGES OF MIXING FOR SYSTEMS OF 4,4'-DI-N-ALKYLOXYAZOXYBENZENES WITH XYLENE. S. D. Christesen\*, R. H. Rhyne, Jr.\*, S. N. Young\*, and R. A. Orwoll. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

Members of the homologous series of 4,4'-di-n-alkyloxyazoxybenzenes are liquid-crystal forming compounds. Thus their phase diagrams show at least one thermodynamically stable phase existing between the crystalline solid and the isotropic liquid. The molecules in this liquid-crystal (or mesophase) phase have an approximately parallel alignment and severely limited rotational mobility. Consequently these substances are anisotropic, viscous fluids.

Binary mixtures of 4,4'-di-n-alkyloxyazoxybenzenes with meta or para xylene as the second component have been prepared. Their temperature-composition phase diagrams show regions with one - in some cases two - anisotropic phase resulting from the presence of a mesomorphic component. Volume changes of mixing are positive for the anisotropic phases. The isotropic solutions show unusual behavior in that the sign of the volume change of mixing changes from minus to plus as the temperature is increased. (Supported by ACS-PRF Grant #8311-B5)

ELECTRON TRANSFER BETWEEN TITANIUM(III) AND RUTHENIUM(III) AMINE COMPLEXES IN CHLORIDE MEDIA. K.M. Davies\*, George Mason Univ., Fairfax, Va. 22030 P. Chailipoyil\* and J.E. Earley\*, Georgetown Univ., Washington, D.C. 20057.

Electron transfer reactions of the ruthenium (III) complexes,  $\text{Ru}(\text{NH}_3)_5\text{Cl}^{2+}$  and  $\text{Ru}(\text{NH}_3)_6^{3+}$  with titanium(III) in acidic LiCl media have been studied kinetically in the acidity range  $[\text{H}^+] = 0.01 - 0.25\text{M}$ . Both reactions are base catalyzed and conform to an experimental rate law which implicates  $\text{TiOH}^+$  as reductant.

The unexpected similarity in both rate and activation enthalpy and entropy noted for the two oxidants is discussed in terms of the chemical peculiarities of  $\text{Ti(III)}$  and  $\text{Ru(III)}$ , particularly the possibility of strong  $\text{t}_{2g} - \text{t}_{2g}$  donor-acceptor interactions being involved in the electron transfer. Such interactions appear to offer no additional advantage in the interchange of  $\text{Cl}^-$  for  $\text{NH}_3$  on ruthenium(III), whereas with the corresponding cobalt(III) complexes ( $\text{Co}^{3+}$  acceptors) a substantial increase in the redox rate is found.

The absence in  $\text{Cl}^-$  media (though not in  $\text{CF}_3\text{SO}_3^-$  media) of expected autocatalytic paths in the reduction of  $\text{Ru}(\text{NH}_3)_5\text{Cl}^{2+}$  is also discussed.

ELECTROCHEMISTRY OF POTASSIUM CHROMATE IN MOLTEN ZINC CHLORIDE-POTASSIUM CHLORIDE EUTECTIC. M.L. Deanhardt\*, Dept. of Chemistry, George Mason University, Fairfax, Va. 22030; and K.W. Hancock\*, Dept. of Chemistry, North Carolina State University, Raleigh, N.C. 27607

The electrochemistry of  $\text{K}_2\text{Cr}_2\text{O}_7$  in an equimolar  $\text{ZnCl}_2$ - $\text{KCl}$  eutectic at  $300^\circ\text{C}$  was investigated by chronopotentiometric, chronoamperometric, and neovolcanometric techniques. The reduction occurs as a single, irreversible, diffusion-controlled step yielding an insoluble electrode deposit that would not undergo electrochemical oxidation. The value of  $\text{nh}^+$  at  $300^\circ\text{C}$  was found to be  $(3.46 \pm 0.10) \times 10^{-3} \text{ eq-cm/mole-sec}^2$ . The charge transfer step was found to be totally irreversible;  $\alpha = 0.37$  and  $k_s$  (at  $1.2 \text{ V}$ ) =  $4.46 \times 10^{-4} \text{ cm}^2/\text{sec}$ . Chemical analyses were performed to determine the composition of the electrode deposit. The deposit appears to be an unstoichiometric compound containing more than one oxidation state of chromium and having the general formula  $\text{K}_x\text{Zn}_y\text{Cr}_z$  where  $x$ ,  $y$ , and  $z$  depend upon the conditions of the electrolysis. A mechanism consistent with the observed results is proposed.

SOME SPECTRAL STUDIES ON PEROXO EDTA TANTALATES. C. Djordjevic and V. A. Culver\*. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

Peroxo-EDTA-tantalates are analogous to the peroxo-EDTA-niobates and can be represented by the formula  $\text{K}_x(\text{M}(\text{O}_2)_2\text{EDTA})(\text{H}_2\text{O})_y$ , where  $\text{M(V)} = \text{Nb}$ ,  $\text{Ta}$ , and  $(x+y) = 3$  to 4. The ir spectra of these complexes reveal information on peroxo and EDTA ligands coordination. Metal sensitive doublets between  $900 - 800 \text{ cm}^{-1}$  show the presence of coordinated peroxo groups. The broad absorption, which does not disappear upon drying, between  $3520 - 3400 \text{ cm}^{-1}$ , can be assigned to protonated carboxyl groups of EDTA, in agreement with a broad peak appearing at  $1660 \text{ cm}^{-1}$ , indicating the presence of coordinated and noncoordinated carboxyl groups, respectively. In the UV spectra of thin solid films a broad band of low molar absorptivity is resolved at about  $240 \text{ nm}$ , and the ligand to metal charge transfer bands do not occur below  $50,000 \text{ kK}$ . The nmr spectra of these complexes indicate the presence of coordinated and protonated carboxyl groups. In addition, nmr spectra show peaks which can be assigned to the acetate groups of the ligand, as well as bands arising from the protons on the ethylenic backbone of EDTA. Splitting is complex, and further studies are in progress to elucidate it.

THE EFFECT OF SULFUR DIOXIDE ON THORNEL 300 GRAPHITE FIBERS. M.L. Eckenrode\*, H.M. Gager, and J.W. King. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

The adsorption of sulfur dioxide and water on Thornel 300 graphite fibers has been studied by the technique of gas-solid chromatography over the temperature range of 20-50°C. The experimental apparatus and modifications on existing equipment will be described as well as a unique column packing technique which allows the examination of fibrous materials in packed columns. Experimentally determined adsorption isotherms correspond to a BET I classification and show a strong dependence on surface treatment for both water and sulfur dioxide. At all temperatures, water is adsorbed to a greater extent than sulfur dioxide. This trend is also found adsorption of these vapors on epoxy-sized fibers as well as water-sized material. The results of accelerated exposure studies of packed fiber beds to sulfur dioxide vapors will be noted, particularly with respect to the adsorption of adsorbates both before and after sulfur dioxide exposure. Finally, the role of surface complexes in determining the adsorption potential of graphite fibers will be discussed.

THE STUDY OF THORNEL 300 GRAPHITE FIBERS BY GAS-SOLID ADSORPTION CHROMATOGRAPHY AND ATR SPECTROSCOPY. M.L. Eckenrode\* and J.W. King. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

The gas-solid interface of Thornel 300 graphite fibers has been characterized using the elution by characteristic point gas chromatographic method. High temperature adsorption data (isotherms, heats of adsorption, etc.) in the temperature range, 100-400°C.) have been determined for model adsorbates. Fiber materials employed consists of both epoxy and water sized fibers upon which adsorption measurements have been made both before and after exposure to SO<sub>2</sub> vapor. Dynamic BET measurements reveal a seven-fold difference in interfacial surface areas between the two treated fibers.

Langmuir type adsorption isotherms are observed for all adsorbates indicating the predominance of adsorbate/adsorbent interactions. The extent of adsorption is highly dependent on adsorbate structure, particularly for the adsorption of polar adsorbates on water-sized fiber. Preliminary ATR measurements suggest the presence of carboxyl and carbonyl functionalities of the fiber surface. Exceedingly higher temperatures were required for thermal desorption of polar adsorbates from the water-sized fiber as compared to those required for desorption from epoxy-sized fiber. The importance of the above data with respect to interfacial adhesion in fiber reinforced materials will be noted.

USING CARBOXYL CARBON-13-PROTON THREE BOND COUPLING CONSTANTS FROM NMR SPECTROSCOPY TO MEASURE CONFORMATION. William G. Espersen\*, Dept. of Chemistry, George Mason Univ., Fairfax, Va. 22030; R. Bruce Martin, Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22901

Three bond carboxyl carbon to  $\beta$ -hydrogen coupling constants are analyzed in terms of rotamer mole fractions estimated from proton vicinal coupling constants for histidine and cysteine derivatives and aspartic acid. Recommended three bond carboxyl carbon to proton coupling constants are 1.3 Hz for the gauche positions and 9.8 Hz for the anti position. It is shown that the predominant rotamer in aqueous solutions of aspartate, neutral and anionic histidine, acylated histidines, and cysteine derivatives possesses an anti disposition of the carboxylate group and the substituent at the  $\beta$ -position. Having both the carbon-carbon and proton vicinal coupling constants removes any ambiguity as to which is the predominant rotamer. Low values of the three bond ester carbonyl carbon and  $\beta$ -hydrogens coupling constants in acetylcholine and acetyl- $\beta$ -methylcholine indicate in aqueous solution a predominance of rotamers about the ether oxygen- $\beta$ -carbon bond with a gauche disposition of the carbonyl carbon and  $\beta$ -hydrogens.

STUDY OF LIQUID PHASE MIXING IN GAS CHROMATOGRAPHIC MIXED BED COLUMNS. P. L. Fitzgerald\*, F. A. Palocsay, J. J. Leary, Dept. of Chemistry, Madison College, Harrisonburg, Va. 22801

Mixed bed columns were prepared using dimethylsilicone (OV-101) and phenylmethylsilicone (OV-17) polymers coated on solid supports of differing size. The mixed bed columns were conditioned at 250°C for times ranging from 10 to 100 hours. Column packings were then separated according to size after which the extent of mixing was studied by monitoring changes in retention behavior.

A MÖSSBAUER STUDY OF SUPPORTED IRON CATALYSTS. Helen M. Gager, Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, Va. 23284

Surface active samples prepared by impregnating high area silica gel with ferric nitrate solutions enriched 90% with <sup>57</sup>Fe retain their activity to surface adsorption following reduction in flowing hydrogen at 900°C. The Mössbauer spectrum of the catalyst is characterized by absorptions at +1.53, 0.69, and 0.20 mm/sec. There is no indication of the presence of zero valent iron. Adsorption of ammonia causes an increase in the quadrupole splitting 1.75 mm/sec but there is no change in the area under the absorption peak. This indicates that the iron is tightly bound to the support.

Additional evidence for the binding of the iron to the support is found on measuring the increase in area of the Mössbauer absorption before heating and after calcining at 600°C.

Measurement of the Debye-Waller factor for a sample oxidized and outgassed at 600°C was found to be 0.75 at 25°C. Although this value is much smaller than that reported for bulk iron oxide, 0.85, the temperature dependence was indistinguishable from the bulk value from 25-450°C.

\*(With respect to sodium nitroprusside)

RATE OF DEGRADATION OF POLYIMIDE PRECURSOR RESINS. M. D. Gibbs and D. E. Kranbuehl. Dept. of Chemistry, College of William and Mary, Williamsburg, Va. 23185

The stability of a series of BTDA-DABP and BTDA-NDA, polyimide precursor resins in DMAC was investigated by measuring their molecular weight as a function of time. The molecular weight measurements were made using a membrane osmometer. The dependence of the rate of degradation on the chemical nature of the isomeric diamine and the geometric structure about the amide linkage was examined and correlated with the basicity of the diamine. The effect of the presence of water and of the temperature was also investigated. The degradation rate was increased three times by the addition of 1(v/v)% H<sub>2</sub>O to the anhydrous solution.

## EXCITON-SURFACE INTERACTIONS IN ORGANIC SOLIDS.

William L. Greer\*, Dept. of Chemistry, George Mason Univ., Fairfax, VA 22030.

To explain large optical absorption line-widths in aromatic molecular crystals at low temperatures, we introduce a line broadening theory which incorporates exciton destruction or capture at the crystal surface. The theory is developed from an intuitive and from a formal viewpoint with substantially the same results when applied to the b-polarized absorption line width of crystalline anthracene at low temperature. Predictions are also made for several other polyacene crystal optical properties. (Supported by the Petroleum Research Fund, administered by ACS).

CHEMICAL MODIFICATION AND QUATERNARY STRUCTURE OF BOVINE MITOCHONDRIAL MALATE DEHYDROGENASE. Eugene M. Gregory\* and Lewis B. Barnett. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Mitochondrial malate dehydrogenase (MDH) from bovine heart muscle is a 70,000 dalton dimer at pH 7.0, with a sedimentation coefficient of 4.5. The enzyme can be inactivated with N-ethylmaleimide (NEM) at pH 5.0 but not at pH 7.0. The inactivation is concomitant with the covalent modification of a sulfhydryl residue, and both inactivation and residue modification can be prevented by addition of the reduced coenzyme, NADH, to the incubation mixture. NEM-modified MDH has a molecular weight of 33,000 and an S value of 2.8-2.9. Addition of 100 mM NADH to the MDH modified protein system results in a species which sediments with an S value of 4.6, indicative of the dimer form. The native enzyme at pH 5.0 has a molecular weight of 33,000 and a sedimentation coefficient of 3.1, but the addition of 50 mM NADH enhances redimerization to the 4.5 S form. These data suggest that the enzyme dissociates to monomers at pH 5.0 and thus exposes a sulfhydryl residue which can be modified by NEM. The addition of NADH prevents the initial dissociation. NEM precludes reassociation of the monomers unless NADH is present.

## PHYSICAL PROBE STUDIES OF MEMBRANE TRANSPORT ENZYMES.

Charles M. Grisham, Dept. of Chemistry, University of Virginia, 22901.

ESR and water proton relaxation rate ( $1/T_1$ ) studies of  $(\text{Na}^+ + \text{K}^+)\text{-ATPase}$  from sheep kidney indicate one tight  $\text{Mn}^{2+}$  binding site per enzyme dimer, with a dissociation constant ( $K_D = 0.88 \mu\text{M}$ ) in agreement with the kinetically determined activator constant, identifying this  $\text{Mn}^{2+}$ -binding site as the active site of the ATPase (C. Grisham and A. Mildvan, J. Supramolecular Structure, 3, 304(1975)). From the paramagnetic effect of  $\text{Mn}^{2+}$  at the active site of the enzyme on  $1/T_1$  of  $205\text{Ti}$  bound at the  $\text{Na}^+$  site, a  $\text{Mn}^{2+}$  to  $\text{Ti}^{4+}$  distance of  $4.0 \pm 0.1 \text{ \AA}$  is calculated, suggesting the sharing of a common ligand atom by  $\text{Mn}^{2+}$  and  $\text{Ti}^{4+}$  on the ATPase. Addition of  $\text{P}_i$  increases this distance to  $5.4 \text{ \AA}$  consistent with the insertion of  $\text{P}$  between  $\text{Mn}^{2+}$  and  $\text{Ti}^{4+}$ .  $31\text{P}$  relaxation studies of  $\text{CH}_3\text{PO}_3^{2-}$  in the presence of ATPase and  $\text{Mn}^{2+}$  yield a  $\text{Mn}^{2+}$  to  $\text{P}$  distance of  $6.9 \pm 0.5 \text{ \AA}$ , suggesting a second sphere enzyme- $\text{Mn}$ -ligand- $\text{CH}_3\text{PO}_3^{2-}$  complex. Terbium fluorescence studies of  $\text{Ca}^{2+}$ -ATPase from rabbit muscle indicate two tight  $\text{Tb}^{3+}$  binding sites per 100,000 MW peptide. Excitation of a  $\text{Tb}^{3+}$ -ATPase solution at 295 nm produces a  $\text{Tb}^{3+}$  emission at 545 nm which is proportional to  $\text{Tb}^{3+}$  concentration up to 2 equivalents per 100,000 MW peptide. Displacement of  $\text{Tb}^{3+}$  with  $\text{Ca}^{2+}$  yields a dissociation constant for  $\text{Ca}^{2+}$  consistent with occupation of  $\text{Ca}^{2+}$  sites on the ATPase by  $\text{Tb}^{3+}$  (Brittain, H., Richardson, F. and Grisham, C., in press).

## STUDY IN THE SYNTHESIS OF 1,6-CYCLODECANEDIONE

Frederick J. Heldrich III\*, Richard F. Rathbone\*, A. Gayden Robert\*, James K. Shillington (Sponsor Member), Earl W. Stradtmann, Jr., Dept. of Chemistry, Washington and Lee Univ., Lexington, Va. 24450

As the route to the 1,6-dione, via the 9,10 decalindiol, has offered poor results to date, we are investigating additional oxidative methods, namely those by permanganate and by ozonization. We hope to convert the  $\Delta^9,10$ -octalin, which we have prepared in fairly high yields, directly to the dione without isolating the individual diol for better yields. The permanganate oxidation proceeds under the usual conditions and is currently under study. We intend further, to prepare the diketone by the standard preparation involving ozone.

The permanganate ion accomplishes oxidation in aqueous solution via the intermediate cis-diol. Under acid conditions we get further oxidation to the diketone. Ozonization, similarly affords an intermediate, the 9,10-ozonide, which yields the 1,6-dione upon reductive work-up.

ANALYSIS OF SOME POLYBUTADIENES BY 13-C NMR. Michael Ku\* and Harold M. Bell. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Low molecular weight hydroxy-terminated polybutadiene, carboxy-terminated polybutadiene, and a copolymer of butadiene and acrylic acid have been analyzed by 13-C NMR. The analysis of these materials, in  $\text{CDCl}_3$  solution, provides information on the 1,2- to 1,4-addition ratio, the cis-trans ratio, and some information concerning polymer microstructure. Also, in the case of hydroxy-terminated polybutadiene, the hydroxyl-bearing carbon atoms were detected. Curing this material with toluene diisocyanate gave a rubber which was also amenable to analysis.

CALCULATION OF ELECTRONIC SPECTRA BY PROJECTED-UNRESTRICTED HARTREE-FOCK THEORY. B. H. Lengsfeld, D. A. Brewer, and J. C. Schug., Dept. of Chemistry, Va. Polytechnic Inst., Blacksburg, Va. 24061

This paper is concerned with a new application of projected Hartree-Fock theory, namely, the calculation of electronic spectra for symmetric molecules. The excited electronic state is represented by a single determinant whose unrestricted nature allows for orbital rearrangement relative to the self-consistent ground state. The self-consistent calculation must be followed by spin projection to obtain appropriate spin eigenstates. It was necessary to develop modified procedures for portions of the spin projection calculation because our method of constructing the wavefunctions produces degeneracies among the natural orbitals. Illustrative calculations using the all-valence-electron INDO approximations produced results which compared favorably with configuration-interaction treatments. The method described here should be most useful, however, in conjunction with *ab initio* calculations using flexible basis sets.

A COMPARISON OF ANALYTICAL TECHNIQUES FOR THE MEASUREMENT OF CHLORIDE IN CONCRETE. R. McCormick,\* J. Reynolds,\* and R. Allen,\* Department of Chemistry, University of Virginia, Charlottesville, VA 22901.

A comparative study of the application of neutron activation analysis, atomic absorption spectroscopy, and analysis by potentiometric titrations with specific ion electrodes to the determination of the chloride content in hardened concrete was made. Precipitation titrations of the acid soluble fraction of chloride in concrete blocks were followed with silver and chloride specific ion electrodes. The silver electrode was particularly useful for determinations of less than 0.2 mg chloride. A method will be described by which the chloride in a sample is volatilized by oxidation with concentrated acid and the free chlorine is collected and reduced in a scrubber solution. The chloride is precipitated with silver ion, and the  $\text{AgCl}$  is collected on a filter, redissolved and the concentration of  $\text{Ag}^+$  is determined by atomic absorption spectroscopy. Data from these two techniques were compared to measurements of the acid soluble chloride fraction made using radiochemical neutron activation analysis.

MACROCYCLIC LIGAND FORMATION IN SOLUTION; KINETICS AND MECHANISM. G. A. Melson,\* Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, VA. 23284.

Although there is an abundance of reported data concerning the synthesis, characterization and reactions of complexes containing macrocyclic ligands, there is little information on the mechanisms by which the ligands are formed in "template" reactions. This paper will discuss some of the factors that are important in controlling the formation of macrocyclic ligands containing four nitrogen donors. The discussion will concentrate on the roles of the metal ion, the reactants, hydroxide ion and the nature of the solvent. The conclusions reached will be based on studies of the kinetics of macrocycle formation reactions made over a range of temperatures and on attempts to detect intermediates. Reaction mechanisms which are consistent with the kinetics will be proposed and discussed. The application of the information obtained to the development of new, improved syntheses of macrocyclic complexes will also be discussed.

THE BIOSYNTHESIS OF THE ANTIBIOTIC, CITRININ. A DRAMATIC DEMONSTRATION OF THE POWER OF CARBON-13 NMR IN SOLVING BIOSYNTHETIC PROBLEMS. William R.C. Munsey,\* and O.R. Rodig, Dept. of Chemistry, University of Virginia, Charlottesville, VA 22901.

The biosynthesis of citrinin by the fungus *Penicillium citrinum* has been shown to occur via the head-to-tail linkage of 5 acetate-derived two-carbon units, along with appropriate alkylations and oxidation-state changes. The question of whether the polyacetate backbone of the molecule is formed from one 5-unit chain or from two chains of 3 and 2 units remains to be answered, and is of particular interest in the light of evidence that sclerin, a metabolite of another fungus which also produces two compounds closely resembling citrinin, may be biosynthesized from 2 chains.

We have studied the biosynthesis of citrinin from diethyl malonate-2- $^{13}\text{C}$  by C-13 NMR, and have found that it proceeds through the formation of a single polyacetate chain. The methods and results of this study, and their significance with regard to the biogenesis of sclerin and its co-metabolites, will be presented.

ALUMINOHYDRIDE REDUCTIONS OF CYCLIC KETONES, II: REDUCTION OF 2-HYDROXYCYCLOHEXANONE. D. M. Murphy\* and T. B. Hill, Dept. of Chemistry, COL. of William and Mary, Williamsburg, VA. 23185

2-Hydroxycyclohexanone (I) was reduced with 1) lithium tetrahydroaluminate (LAH), 2) lithium trimethoxyhydroaluminate (LTMAH) and 3) lithium tri-*t*-butoxyhydroaluminate (LTBAH) to provide high yields of *cis*- and *trans*-1,2-cyclohexanediols (II) in many cases. Amounts of *cis*- vs. *trans*-isomer were measured by gas chromatography. LAH and LTMAH liberate 35 to 105 percent hydrogen, based on (I) during reduction which suggests a reaction between these reducing agents and (I) prior to reduction. LTBAH provided little hydrogen during reduction suggesting a direct attack of reducing agent on the carbonyl group of I. However, increasing molar excesses of LTBAH vs. (I) at -78° provided more hydrogen (12% H<sub>2</sub> at 2.66 molar excesses of LTBAH) and less *cis*- (vs. *trans*-) diol (II) in the products. These results are contrasted against those of H. C. Brown [J. Am. Chem. Soc., 87, 2720 (1965)] in his studies of similar reductions on 2-alkylcyclohexanones.

MANGANESE CATALYZED OSCILLATORY REACTIONS, G. W. Mushrush and E. V. Mielczarek, George Mason University, Fairfax, VA. 22030

A potentiometric study of the manganous ion (and manganous ion complexes) catalyzed oscillatory reactions with malonic, and malic acids is reported on.

Metal ions other than iron and cerium and non metal ions whose potentials are similar to the manganous system do not catalyze oscillatory reactions.

The reactions were monitored with both platinum and ion sensitive electrodes.

ENERGY TRANSFER IN FROZEN SOLUTION. G. W. Mushrush, G. Yonushchot and D. Rose\*, George Mason University, Fairfax, VA. 22030

Lanthanide ions such as  $\text{Eu}^{+3}$  are known to be efficient scavengers of triplet state energy. Since excited rare earth acceptors exhibit measurable fluorescence, they can be used for quantitative evaluation of the transfer process.

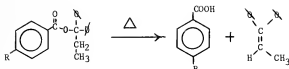
Transfer of triplet electronic excitation energy from mononucleotide donors to lanthanide ion acceptors in EGW (1:l) glass was monitored by measuring the quantum yield of nucleotide and lanthanide ion luminescence at different lanthanide ion concentrations. A suggested photokinetic scheme consistent with the presumed exchange mechanism explains the observed behavior.

REACTIONS OF METHYLENE RADICALS WITH ACETYLENE. M. A. Neely\*  
R. F. Cozzens, Dept. of Chem., George Mason University,  
Fairfax, Va. 22030

Gas phase photolysis of mixtures of acetylene and ketene were carried out at wavelengths of 254 nm and 366 nm at partial pressures of 2.0 and 1.0 torr respectively. Ketene was prepared by the pyrolysis of acetic anhydride at 600°C. and subsequent purification by low temperature distillation. Relative amounts of the products methylacetylene and allene were monitored by FID gas chromatography. Results indicated a ratio of methylacetylene to allene (MA/A) four fold larger for short wavelength radiation than for long. It was concluded that triplet state methylene radicals predominantly found by long wavelength photolysis of ketene react with acetylene producing allene whereas singlet methylene radicals react by insertion forming methylacetylene.

LOW TEMPERATURE PYROLYSIS OF SOME SUBSTITUTED BENZOATE ESTERS, Raphael M. Ottenbrite and Pamela Jordan\*, Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, Virginia 23284

A series of para-substituted benzoate esters were prepared with 1,1-diphenylpropanol. These compounds were found to undergo neat decomposition at temperatures (<1500°) which is much lower than for the corresponding acetates (>3000°)



Further investigation in solution decomposition revealed even lower temperatures of decomposition of 100°C was possible. Autocatalytic effects were observed when the reaction was 50% complete in the two solvents studied DMSO and pyridine. The decomposition followed first order kinetics and correlated with Hammett plot.

UNIQUE NMR SHIFTS DUE TO INTRAMOLECULAR HYDROGEN BONDING TO NITROGEN. Raphael M. Ottenbrite, B. L. Stump and Michael Runge,\* Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, Va., 23284.

The proton nuclear magnetic resonance chemical shifts of N-methyl and certain other hydrogen atoms of 1-(N,N-dimethyl-1,2-ethanediamino)-1,2,2-tricyanoethylene, 1-(N,N-dimethyl-1,3-propanediamino)-1,2,2-tricyanoethylene, and 1-(N,N-dimethyl-1,4-butanediamino)-1,2,2-tricyanoethylene showed significant downfield shifts. Comparison of the nuclear magnetic resonance and infrared spectra and physical characteristics with the respective quaternary hydrogen chloride salts and with 1,1-bis (N,N-dimethyl-1,2-ethanediamino)-2,2-dicyanoethylene, 1,1-bis (N,N-dimethyl-1,3-propanediamino)-2,2-dicyanoethylene and 1,1-bis(N,N-dimethyl-1,4-butanediamino)-2,2-dicyanoethylene it was evident that strong N-H...N bonding involved.

Preliminary X-ray studies and molecular weight determination by thermoelectric measurements indicated that this N-H...N interaction was intramolecular.

ON THE TRAIL OF THE EARLIEST INHABITANTS OF VIRGINIA OR HOW NEUTRON ACTIVATION ANALYSIS CAN AID ARCHAEOLOGISTS, S.E. Pennell,\* K. K. Allen\* and R. O. Allen\*, Department of Chemistry, University of Virginia, Charlottesville, VA 22901.

Neutron Activation Analysis has been used as an analytical probe in fingerprinting the geographic origins of archaeological soapstone samples. Soapstone, being a fairly soft lithic material, was easily carved into both pragmatic and aesthetic products by the American Indians. Soapstone was only formed in certain regions of North America, causing these pieces often to be subject to trade with inhabitants of other areas. Due to the nature of the geochemical processes involved in its formation, soapstone may be fingerprinted geographically because its elemental composition varies according to the physical source. Soapstone is therefore a judicious choice in an archaeological study of trade and travel routes of the Indians. Neutron Activation Analysis was chosen as the analytical technique because it meets many of the practical prerequisites for a rapid multielement analysis. In our work, we are attempting to characterize the soapstone outcroppings in the southeastern regions of the U.S., and to locate the original sources of artifacts.

ANALYTICAL CHEMISTRY FOR PRE-MEDICAL STUDENTS. George M. Pickral, Dept. of Chem., Va. Military Inst., Lexington, Va. 24450

The content of a one semester analytical chemistry course for pre-medical students was studied by conducting two surveys. In the first survey the "Professor of Analytical Chemistry" at 120 colleges rated topics as to importance using a scale of A to D. The tabulated results were the basis of a second questionnaire sent to medical and dental schools. Eighty percent of the 70 replies came from Professors of Biochemistry with 13% from course coordinators and 7% from members of the admissions committee. These professors were asked to indicate desirable changes in the importance of topics as rated by the analytical professors. A comparison of the two surveys revealed several topics where there was a sharp difference of opinion between the two groups. These differences were discussed during visits to seven medical schools and ten colleges in North Carolina, Virginia, Maryland, Louisiana, and the District of Columbia. Changes which have been made in the analytical chemistry course at VMI will be discussed.

THE LASER-INDUCED FLUORESCENCE OF GAS PHASE CS<sub>2</sub>. S. J. Silvers\* and M. R. McKeever\*, Dept. of Chemistry, Virginia Commonwealth Univ., Richmond, Va. 23284.

Fluorescence from gas phase CS<sub>2</sub> has been excited with a pulsed nitrogen laser. The fluorescence is dispersed revealing progressions of sharp bands in the near ultraviolet and a broad, continuous emission with superimposed bands in the visible. Lifetime decay measurements indicate that two excited electronic states give rise to the fluorescence. A shorter-lived one gives rise to the sharp emission bands, while a longer-lived one produces the continuum-like emission. Zeeman effect measurements indicate that both states are singlet in nature. The experiments help characterize the complex and interacting manifold of excited electronic states of CS<sub>2</sub> in the region of the nitrogen laser excitation.

COORDINATION CHEMISTRY OF IMIDAZOLES. R. J. Sundberg, D. C. Monte,\* and Ibrahim Yilmaz, Dept. of Chemistry, University of Virginia, Charlottesville, VA 22901.

Several pyridyl, pyridylmethyl and aminoalkyl imidazole which could act as bidentate ligands in a carbon-bound mode have been synthesized. The complexes of these ligands with Co(II), Cu(II), and other divalent first row transition metal ions have been investigated by nmr and uv-vis spectroscopic techniques in solution and by X-ray diffraction in the solid phase. No evidence of carbon-bound structures has been detected with the ions of the first transition series. The coordination chemistry is evidently dominated by the greater basicity of the pyridine-type nitrogen of the imidazole ring.

In DMSO solution the structure of the cobalt complexes depends upon the anion with tetrahedral geometry being adopted with halide salts and octahedral coordination in nitrate salts.

NON-RIGID MOLECULE EFFECTS ON THE ENERGY LEVELS OF XeF<sub>6</sub>.

Carl O. Trindle, Department of Chemistry, University of Virginia, Charlottesville, VA 22901.

The geometric and electronic structure of XeF<sub>6</sub> is not yet fully understood, even though most of the means of structure determination available to the chemist have been employed in an effort to describe the molecule. We suggest that many of the experimental anomalies and theoretical difficulties arise from the possibility of rapid polytopal rearrangement in this system, and put forward in this report an analysis which accommodates the experimental data. We show that easy rearrangement produce substantial splittings in rigid-molecule energy levels, and with the aid of Longue-Higgins group theory developed expressly for flexible molecules, compute energy-level schemes for a set of plausible rearrangement modes. By appropriate choice of parameters specifying the extent of splitting, we match the reported infrared and Raman spectra, and their temperature dependence. The puzzling "time lag" in the Raman (but not the infrared) spectrum is tentatively ascribed to selective relaxation of Raman-active vibrational modes.

ALKYLATION OF ALKENOLS AND ALKYNOLS PROMOTED BY COMPLEXATION WITH TITANIUM. H. E. Tweedy, C. M. O'Doherty, P. E. Hahn, R. A. Coleman, and D. W. Thompson, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

The accepted mechanism for the Ziegler catalyzed polymerization of unsaturated hydrocarbons has been adapted to effect the alkylation of unsaturated alcohols. We have synthesized [Ti(acac)<sub>3</sub>(OR)Cl] (R=CH<sub>3</sub>, C<sub>2</sub>H<sub>5</sub>, etc.) complexes which in combination with organoaluminum compounds catalyzed the polymerization of ethylene to linear polyethylene. The observed catalytic activity for the [Ti(dik)<sub>2</sub>(OR)Cl] complexes and the fact that chain growth occurs at titanium led us to postulate that unsaturated alcohols, incorporated into titanium complexes, could be alkylated intramolecularly when reacted with organoaluminum compounds. Hydrolysis would then yield the hydroalkylated alcohol. Reacting [Ti(acac)<sub>3</sub>(OR)Cl] complexes, R=3-butenyl, 3-butenyl, 3-pentenyl, and 4-pentenyl, with Al(C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>Cl at temperatures of 0° and -78° gave moderate yields of terminally ethylated alcohols. Deuterium could be incorporated by hydrolysis with D<sub>2</sub>O; iodination gave an iodo-alkylated product. Complexes such as TiCp<sub>2</sub>Cl(OR) and TiX<sub>3</sub>(OR) also gave ethylated products.

CHARACTERIZATION OF DIMETHYL ETHERS OF POLYETHYLENE GLYCOL BY HIGH SPEED GEL PERMEATION CHROMATOGRAPHY. J. A. Welch and J. W. King, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284

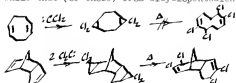
The molecular-weight distribution of polyethylene glycol dimethyl ethers has been determined by high speed gel permeation chromatography encompassing polymers whose M.W. ranges from 400 to 4000 a.m.u. Polymers were synthesized by end-capping polyethylene glycols of varying M.W. with a methoxy group via conventional etherification methods. A bank of four micro-Styragel columns of varying porosity, 10<sup>5</sup>, 10<sup>4</sup>, 10<sup>3</sup>, and 500 Å were employed to effect fractionation. Column calibration was performed using polystyrene and polypropylene glycol standards eluting in tetrahydrofuran.

Initial calibration plots show a difference in the solution behavior of the two sets of standards. Data will be presented to show the dependence of the experimental polymer M.W.'s on the choice of calibration curve. Universal calibration was attempted using polystyrene standards and associated intrinsic viscosities. Experimentally determined molecular weights show good agreement with the results obtained via thermoelectric and IR techniques when polystyrene calibration plots are used. Poor agreement is found for the molecular weights of the experimental polymers when universal calibration plots are used. Possible sources of error attributable to universal calibration methods will be discussed.

BICYCLIC COMPOUNDS AND CARBENE DERIVATIVES. G.S. Whitney and R.C. Wisman\*, Dept. of Chemistry Washington and Lee University, Lexington, Virginia 24450.

The reaction of dichlorocarbene with olefins, discovered by Doering more than 20 years ago, has been used in the Makosza modification using a phase transfer catalyst to make derivatives of norbornene and dicyclopentadiene, as well as 1,5-cyclooctadiene.

In agreement with the finding that 6,6-dichlorobicyclo [3.1.0] hexane, the dichlorocarbene derivative of cyclopentene, expands, on heating, to 2,5-dichlorocyclohexene and that the corresponding cyclohexene derivative does not expand [only 7,7-dichlorobicyclo[4.1.0] heptane round], we found that the derivative of 1,5-cyclooctadiene would not expand, while that (or those) from dicyclopentadiene would.



ROTATIONAL RELAXATION PROPERTIES OF MOLECULES IN THE SUPERCOOLED LIQUID STATE. C. A. Wilkes\* and D. E. Kranebuhl, Dept. of Chemistry, College of William and Mary, Williamsburg, Va. 23185

The dielectric behavior of solutions of chloroform, t-butyl chloride, t-butyl isocyanate, 2,2'-bipyridine, nitrobenzene, p-nitrophenyl, m-nitrophenyl, o-nitrophenyl and 2,2'-dinitrophenyl in o-terphenyl at supercooled liquid temperatures was examined. The relaxation time characterizing rotational diffusion at supercooled liquid temperatures was determined by measuring the frequency dependence of the permittivity. The values of the relaxation time and their temperature dependence for all of the molecules studied were similar to the relaxation properties for pure o-terphenyl. The results support the view that relaxation occurs as a cooperative process in which the solute and solvent molecules relax together.

## THE SYNTHESIS AND CHARACTERIZATION OF NEW BISMALEIMIDE

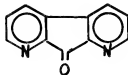
MONOMERS. R. L. Williams and R. Brown. Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508

Recent advances in the field of high temperature polymers has prompted an investigation into the synthesis of several novel and new bismaleimide monomers. The reaction of dimethyl maleic anhydride with various aromatic and hetero-aromatic diamines and aromatic tetraamines will be discussed together with pertinent structural and spectral data.

CARBONYL DERIVATIVES OF 1,8-DIAZAFLOURENON-9. R.L. Williams and Gretchen Williams, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

1,8-Diazaflouren-9, (1) was prepared from the 4,7-phenanthroline-5,6-quinone. A number of carbonyl derivatives were prepared and carefully examined with ir and nmr spectroscopy. The most interesting products were found to arise from the condensation of (1) and oxalyl chloride and 4-amino-1-methylpiperazine.

(1)



## Section of Education

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

A WEATHER RECIPE FILE BOX--A PROJECT FOR THE ELEMENTARY SCHOOL. M. K. Clarke\*, and E. M. Hairfield, Mary Baldwin College, Staunton, Va. 24401

Like a cake, weather is a final product created from a mixture of many different ingredients. One can make many different kinds of cakes simply by changing proportions or changing ingredients. Similarly each weather condition has a unique recipe. In a weather recipe the instructions generally call for a certain measurement of latitude and altitude, mixed together and stirred with proximity to oceans and currents. After baking for a specified time according to the season, one ends up with a particular weather condition --the "weather cake".

A child in the upper elementary school grades who has studied these ingredients that make up weather can construct his own recipe file box. Clear instructions for constructing a recipe box for Virginia will be presented and the completed "recipes" will be used to "bake" a few sample weather cakes.

FLUORESCENCE. H. I. Feinstein. Department of Chemistry, George Mason University, Fairfax, Va. 22030

After a brief introduction to the nature of radiation with special reference to the UV region of the electromagnetic spectrum, a popular presentation of fluorescence will be given. This will include terminology, sources of UV, measurement, and applications. Fluorescent minerals, indicators, phosphors, fluorimetric reactions, and chemiluminescence will be demonstrated. The demonstrations will require only simple equipment that is easily adapted for use in general chemistry courses and for popular science lectures and science shows.

SOME OBSERVATIONS AND DEMONSTRATIONS IN THE TEACHING OF GENERAL CHEMISTRY. H. L. Feinstein and Scott Estes\*, Dept. of Chemistry, George Mason Univ., Fairfax, Va. 22030

Recent articles and letters to the editor by academic chemists as well as industrial chemists have indicated that very often the general chemistry course has become highly sophisticated and out of touch with reality. The result has been that students have not had the contact with and knowledge of chemicals and techniques that one would normally expect them to have by the time they reach a more advanced stage in their training.

Examples will be cited where fundamentals have been successfully employed in solving actual consulting problems. There will also be a discussion of how fundamentals can be used in newly devised laboratory and demonstration experiments that should be both interesting and informative to the embryo chemist.

TEACHER/STUDENT PERCEPTION OF TEACHER EFFECTIVENESS. Jack K. Fletcher, Neil G. Pedersen\*, Sch. of Education, Univ. of Virginia, Charlottesville, VA 22901

Numerous previous studies have focused on the relationship between teachers' self-concept and their effectiveness in the classroom. It has been suggested that teachers with higher self-concepts are rated superior to those with lower self-concepts. This study was undertaken to investigate more closely the relationship between teacher self-concept and effectiveness as perceived by their students.

Nineteen teachers participating in an earth science inservice course in a western VA city were administered the Tennessee Self-Concept Scale and were asked to rate themselves with the Illinois Ratings of Teacher Effectiveness questionnaire (IRTE). Subsequently, the same teachers administered the latter instrument to two of their class sections. Teachers were divided into three groups based on their self-concept scores. It was hypothesized that each group would differ significantly in terms of students' ratings of their effectiveness; further, a curvilinear relationship was predicted. A one-way analysis of variance was conducted with an orthogonal contrast to test these hypotheses.

Among the IRTE sub-scales, significant differences were found in personal appearance, explanations, grading, enjoyment of teaching, voice, knowledge of subject and total score. A curvilinear relationship existed in each of the cases with the teachers in the middle range of self-concept rating the highest.

ISIS: AN UPDATE. R. N. Giese, School of Education; The College of William and Mary, Williamsburg, Va. 23185

ISIS is modularized, self-paced and activity oriented. Each minicourse treats a topic of consequence to students, is usually independent of others and contains core, advanced and excursion activities. The core develops the minimum objectives. Advanced activities emphasize scientific principles. Excursions extend the core. Reviews by the ISIS and NSF staffs reduced the proposed minicourses to 65. Minicourses treating "pure science" or peripheral topics were cut.

Each core and advanced section has a planning activity. For each activity it lists the objective(s) to be met and states a sample question. If the sample question and several starred questions in an activity itself are correctly answered, the activity is skipped. Each objective is measured by a question on each of two forms of the minicourse tests. A 70% pass rate for a minicourse test item is desired before an activity is accepted for final revision and commercial form.

Cluster tests will determine if students completing several related minicourses can synthesize the aspects of concepts in different minicourses into a whole.

DISCIPLINE IN INTERMEDIATE SCIENCE CURRICULUM STUDY (ISCS). Calvin C. Green, Head, Science Department, Thomas Jefferson High School, Richmond, Virginia 23230

This study was designed to evaluate the disciplinary problems associated with "Open Concepts" of classroom instruction at Thomas Jefferson High School, ISCS, Level III is the final sequential phase of a three-year intermediate science program. The course is individualized, self-paced, activity centered, and it uses a multitask approach. Level III is composed of eight separate sub-courses in earth science and life science. The philosophy of the course is student discovery by activities and investigations. Evaluation in the course is based on performance objectives.

Since discipline has been number one among the school problems in the Gallup polls for the past several years, and since students are experiencing unusual liberties at the present time, I made this study on the "Behavioral Analysis Classroom Interaction" approach. This is our second year of teaching ISCS, Level III at Thomas Jefferson High School, and the study involves three current ISCS classes in which at least sixty-five students voluntarily completed an "Interaction Survey". The surveys were taken in mid-January, 1976.

The study shows that students understand the sources and the effects of poor discipline in the schools. It shows that they appreciate directed discipline.

INSTRUCTIONAL TECHNIQUES IN SCIENCE AS A FACTOR INFLUENCING READING COMPREHENSION: Dillard Haley, State Department of Education, Radford, Virginia 24141

Over the past several years the teaching of reading has received great emphasis. Reading programs have sometimes been implemented at the expense of science programs. The purpose of this paper is to compare the gain in reading ability for students engaged in science activities to other segments of the student population.

The Instructional Techniques used in several science programs are accompanied by significant mean gain in scores on designated reading tests.

ASSESSING COGNITIVE STYLES AND THEIR NEED IN SCIENCE EDUCATION. Lubna R. Ijaz, College of Education and M. A. Ijaz\*, Department of Physics, VPI&SU, Blacksburg, VA. 24061

Human behavior can be classified into three groups: behavior that is common to all, behavior that is common among some and behavior that is unique to an individual. As a result of Piaget's work behavior common to all of us is better understood - but behavior unique to an individual has not been researched thoroughly so far. Cognitive style is that part of learning behavior that is unique to an individual. It is one's specific mode of perceiving, remembering and thinking and utilizing new information. The purpose of this study is to define the most significant five cognitive styles and their implications in science teaching. Tests designed for assessing cognitive styles will be discussed.



LEARNING AND COMMUNICATION MODEL FOR USE IN SCIENCE CLASSROOM. Lubna R. Ijaz, Thomas G. Teates\*, College of Education, and H. A. Ijaz\*, Department of Physics, VPI&SU, Blacksburg, Va. 24061

In a learning environment communication results from complex motivational system on the part of both teacher and student. It is, therefore, important to recognize certain factors in motivation and behavior, as well as a number of other variables associated with any interpersonal confrontation. Learning may result from perception of one's own needs and to relate it to others' actions. In our learning and communication model we will discuss ways and means of teaching more science to all ability students. We have tried to make study of science interesting and fun for students and have tried to motivate them. Students have shown better achievement on standardized tests in our way of teaching as compared with conventional lecture-recitation method.

LABORATORY SAFETY-IS YOUR LAB SAFE? SAFETY SYMBOLS AND RISK SCALE. Franklin D. Kizer, Supervisor of Science, State Dept. of Ed., Richmond, VA 23216.

Safety is an integral part of science instruction. The analysis of the risk involved in an activity is an objective of most science instructional programs. The increasing concerns of the general public over hazardous environmental conditions has supported the need for safety instruction, and science teachers are constantly being made aware of dangers associated with newly developed materials. Recent studies revealing hazards associated with common materials previously considered safe, have caused concern among many instructors and administrators.

It is very difficult for an instructor or student to know of every hazard associated with all of the materials used in a given program. A laboratory safety check list, risk scale, and other aids should be helpful to the teacher in developing a safety program.

Safety symbols have been prepared to give a comprehensive coverage and immediate recognition of a potential danger. The deVinci man is surrounded by twelve circled safety symbols. Each symbol representing one major area of safety.

ENVIRONMENTAL EDUCATION: K-12. H. B. Lantz, Jr.,\* Orange County Public Schools, Orange, Va. 22960, and Marilyn Bodkin, Dept. of Biology, Madison Col., Harrisonburg, Va. 22801

One of the richest sources of direct experience is the environment, both natural and manmade. By utilizing environmental concepts and by providing direct experiences with the environment, a teacher can successfully lay a foundation for the necessary abstract experiences required in many disciplines and at the same time initiate an interest in and concern for the environment. This philosophy forms the basis for operation of Project COMSEP. COMSEP (Comprehensive School Environmental Program) is an ESEA Title III project that is multi-disciplinary in approach and which enriches and supplements the existing curriculum at all grade levels. Utilizing locally developed curricula and resources, the program provides learning experiences in environmental education for approximately 4,000 students in grades K-12. Evaluation instruments administered to participating students revealed significant differences ( $p < .05$ ) in Environmental Attitude and Environmental Information Surveys on a pre- and post-test design. Additionally, participating teachers demonstrated significant gains in environmental knowledge and positive changes in both environmental attitudes and teaching behavior.

A PRACTICAL CLASSROOM SEISMIC SYSTEM FOR EARTH STUDIES ENRICHMENT. James D. Lehman, Dept. of Physics, Madison Col., Harrisonburg, Va. 22801

The feasibility of a classroom type seismic system is explored in an effort to make this fascinating topic of geological science a part of the usual observational and investigative techniques of the scientific classroom.

The overall system design took into account simplicity and reliability, with economical costs of construction and maintenance. A modified Milne cantilever sensor was designed with a pendulum period of twelve seconds. Magnetic damping is employed while an op-amp/amplifier magnifies the output coil current to a graphic ink recorder for a velocity readout.

A data base was established by six months of continuous recording completed March 31, 1976. A total of 76 detections were observed, with six being atomic nuclear test blasts. Microseismic activity included the usual 3-6 sec. background activity, and some local and thermal noise. The effect of winter cold frontal movements into the North Atlantic area were pronounced.

The variety of records resulted in several characteristic P, S & L wave profiles. The influence of the Earth's core was evident in epicentral distances greater than 100 degrees. The system lends itself to open-ended analysis in terms of directional characteristics, magnitude and phase determinations.

FIELD WORK IN VIRGINIA'S SECONDARY EARTH SCIENCE CLASSES. Jack L. Mason, Erle Thompson, Sci. Ed., Univ. of Va. Charlottesville, Va. 22903

Virginia's 1974-75 Earth Science Teachers were surveyed to determine the status of field work in earth science. Analysis was by the SPSS computer program using means, frequencies, t tests and multiple regression techniques.

There appears to be a trend toward more field work in Virginia. In 1974-75 over 60% of the teachers conducted four or more trips with only 17% failing to conduct field activities. These results are much better than those of studies done during the early 70's in Virginia and other states.

Teachers would prefer to at least double the time spent with field work. Significant increases in both the total number of field sessions and total instructional hours with field work were preferred. Significant increases were also preferred for time devoted to various field practices.

Other findings revealed that: (1) only twenty-five of the state's teachers could be classified as having highly active field programs, (2) numerous hindrances to field work were perceived by teachers, (3) teachers felt that state and local educators should cooperate with other agencies to compile materials for suitable field sites, (4) teachers want more in-service courses designed to develop field techniques useful in the school community, and (5) the only strong predictor of time a teacher will spend with field activities is the teacher's interest in doing personal field work.

THE RELATIONSHIP OF SELECTED VARIABLES TO ACHIEVEMENT IN GENERAL BIOLOGY AT THOMAS NELSON COMMUNITY COLLEGE.

Furner M. Spencer, Dept. of Biology, Thomas Nelson County Col., Hampton, Va. 23670

The relationship of selected variables to achievement (as measured by grade point average) in general biology was determined by conducting a Pearson-product moment correlation and a stepwise multiple regression. A random sample of 140 students was drawn from a list of 582 students who had taken biology during the academic years 1970 through 1973. The SPSS computer programs were used.

The following correlation ( $r$ ) values resulted: HSGPA ( $X_1$ ), 0.3958; CGP biology interest score ( $X_2$ ), 0.2619; CGP math score ( $X_3$ ), 0.2906; CGP verbal score ( $X_4$ ), 0.2421; SCAT quantitative score ( $X_5$ ), 0.1544; CGP motivation score ( $X_6$ ), 0.1059; and SCAT verbal score ( $X_7$ ), 0.2160. All variables correlated significantly with the biology grade point average ( $Y_1$ ) except SCAT quantitative score and CGP motivation score. The stepwise multiple regression produced the following prediction equation: ( $Y_1$ ) =  $-.0067 + .3679(X_1) + .0179(X_2) + .0171(X_3) + .0115(X_4)$ . This equation showed a multiple  $R$  value of .5078.

It was concluded that the best single predictor of success in general biology was the HSGPA. CGP biology interest score, CGP math score, and CGP verbal score were also useful in predicting the biology grade point average. In general, ability tests alone were not the best predictors of success. Previous achievement and interest were also important.

ALGEBRA II INSTRUCTION FROM AN APPLIED STANDPOINT DOES IT AFFECT STUDENT PERFORMANCE IN SCIENCE COURSES? H. W. Straley, F. A. Straley\*, R. P. Graves  
Dept. of Mathematics, Woodberry Forest Sch., Woodberry Forest, Va. 22989.

Mathematics is in part an effort to define models of real world situations. An Algebra II program designed to illuminate mathematical modeling is described in this paper. Examples of class activities, applied problems, and expository text book material is described. Preliminary research to determine if this approach to Algebra II can improve chemistry problem solving skills has been encouraging and the results of this study are briefly outlined.

## Section of Engineering

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

HYBRID POWER SOURCE FOR VEHICULAR PROPULSION. E. D'Amico, J. B. O'Sullivan, I. R. Snellings and M. Jakola: Electrochemical Division, MERADCOM Fort Belvoir, VA 22060

A hybrid power source is one that is composed of two separate sources which are interrelated and can operate in unison. Typically the primary source is characterized by a high energy density; the secondary or storage source by a high power capability. The primary source supplies the base or "average" power requirement; the secondary source the higher transient demands. When the load demand falls below "average", the storage source receives available excess power. The transient demands upon the primary source, though not eliminated, are reduced in frequency and amplitude. This allows for design & operation of the primary source near the same point, usually optimum efficiency.

A fuel cell-battery hybrid power source has been designed and installed in an electric fork lift truck. The design was based on data obtained by the instrumentation of an electric lift truck operating at an Army depot. Field information indicated that lift truck load demands matched those characteristics requisite for a hybrid power source; high peak to average load, high frequency of occurrence & rapid load change. This power source has been tested via a unique facility that utilizes the magnetic tape recordings from the field for control of the load demand. This testing has supplied information relating to load sharing between the sources, energy transfer through the sources, conversion and transfer efficiencies, and control, performance and interfacing requirements.

COMPUTER AIDED PART PROGRAMMING. A. DuPont\*, J. J. Kaulzlarich, and E. V. Mochel\*. Mechanical Engineering Dept., School of Engr. and Applied Science, Univ. of Va., Charlottesville, VA. 22901

CAPP is a BASIC computer program which enables the user to describe the geometry of a part to be machined by a numerically controlled machine tool. The program is primarily geometric in nature, and will perform a large variety of calculations for the user, greatly simplifying and speeding the preparation of a tape for use on the NC machine. The program allows the user to verify the shape through use of a remote plotter, and the final output is the punching of a paper tape in the correct format for use on the control.

This language also provides circular and linear interpolation to specified tolerances, allowing a positioning numerical control to be used as a contouring numerical control.

The capabilities of the CAPP language will be illustrated by following through the typical sequence of steps a user would follow from initial design concept to the final machined part.

APPLICATION OF LAGRANGIAN DISPERSION MODEL TO THE LAFAYETTE RIVER, NORFOLK, VA. Alan J. Farling,\* Carvel H. Blair,\* and Chin Y. Kuo. Dept. of Civil Engrg., Old Dominion Univ., Norfolk, Va. 23508.

An existing one-dimensional network model, of Lagrangian formulation, is used to predict dispersion in the Lafayette River; an estuary in coastal Virginia. The model, as presented by Brandsma, Lee and Bowerman (June 1973), follows individual elements of water as they move along one-dimensional channels in response to flows. A dimensionless mass transfer coefficient determines the amount of dissolved material exchanged between elements by dispersion and diffusion.

Minor modifications were made to the model so as to be able to run it on available computer hardware and to adapt it to the Lafayette River. Significant modifications include doubling the size of the model and adding the option to assign a unique Manning number to each segment.

Based on the field data collected, the model was calibrated and verified. The model accurately predicted tide stages and mean velocities. It also accurately predicted dye distribution in the reach of the estuary with uniform salinity. However, it failed to accurately predict dye distributions in reaches of the estuary with non-uniform salinity.

A PASSIVE RADAR TECHNIQUE. J. M. Franke\*, NASA-Langley Research Center, Hampton, VA 23665

Presented will be the basic theory of a passive radar technique in which several radar sites are served by a common illuminating source radar but have independent noninterfering receivers. The receivers are used to determine range information by a timing relationship between the time of flight differences in the reception of direct pulses and reflected pulses from the source radar. The determination of azimuthal direction is dependent on the basic configuration of the source transmitter. This technique permits expansion of service without an increase in spectrum space. Also discussed will be the hardware for a proposed system utilizing UHF television transmissions as the illuminating radar. A correlation technique will be used to determine range and the orientation and beamwidth of the receiving antenna will determine azimuth direction.

NEAR-TERM TECHNOLOGY ASSESSMENT OF SOLAR CLIMATE CONTROL SYSTEMS. G. Hesselbacher\*, M. Loew\*, G. Marcus\*, J. Morris\*, D. Spalding\*, and D. Walker\*. Analytic Services Inc. (ANSER), 5613 Leesburg Pike, Falls Church, Virginia 22041

This paper describes recent ANSER research on tools for solar energy research and development decision making. That research has produced a methodology for assessing the cost impact of potential technological improvements to solar heating and air conditioning systems in the 1975-1985 time frame. The methodology uses relative cost reduction for a fixed-task system as the measure of effectiveness for each such improvement. That measure is applied to solar collector, absorption air conditioner, and solar storage subsystems to find potential improvements which offer large relative system-cost reductions.

ENERGY CONSERVATION THROUGH IMPROVED BUILDING MANAGEMENT. F. L. Hucksstep\*, L. S. Fletcher, and J. C. Templeman\*. Dept. of Mechanical Engineering, Univ. of Va., Charlottesville, VA 22901.

The Energy Conservation Committee for the University of Virginia began an intensive energy conservation program in the Fall of 1976 in an effort to reduce its utility costs. Initial reductions in energy usage were made by reducing or shutting off heating and ventilating equipment in various buildings during evenings, weekends, and holidays. Buildings were surveyed to ascertain what modifications could be made to reduce energy consumption. Building temperature levels, lighting levels, heating levels, and usage patterns were considered. An in-depth study was made to determine the effectiveness of energy conservation measures in the Mechanical Engineering Building. This study was used to project potential cost savings for various building operating conditions.

The experience at the University of Virginia has demonstrated that judicious building management can result in significant energy savings over a short period of time and for a small investment of time and money.

COMPUTER SIMULATION OF SOLAR-ASSISTED RESIDENTIAL HOT-WATER SYSTEMS. L. U. Lilleleht, M. D. Duvall\*, Dept. of Chem. Eng., and J. T. Beard\*, Dept. of Mech. Eng., Univ. of Va., Charlottesville, Va. 22901

A computer simulation of the energy requirements for domestic hot water in a typical single-family residence was undertaken to evaluate the feasibility of solar energy for reducing the power requirements of conventional electric water heaters. Major components of the simulated system were: 52-gallon electrically heated hot water tank, a flat-plate solar collector array, a heat exchanger between the collector and storage loops, and circulating pumps with their associated controls. The design and operating parameters investigated included the collector area, heat exchanger area, flow rates through the collector and storage loops, and location of the electric heating element in the water tank. The simulation accounted for thermal stratification by dividing the tank into a finite number of strata. Temperature within each stratum was assumed to be uniform. Heat is exchanged between strata by bulk flow, and conduction. Finally, annual costs of solar-assisted systems were estimated and compared with those for conventional electric water heaters over an expected 10-year life.

THE FUTURE OF ENERGY. C. Hardy Long, F.E., Dept. of Mechanical Engineering, V.P.I. & S.U., Blacksburg, Va. 24061

The simplest prediction of the future of energy would be to say that no one is going to worry or do anything to save or prevent inefficient use of energy on this earth. We are going to use that source abundantly available to us at the moment.

Those of us who study the use of energy and sell equipment that uses energy can now help but be conscious of the alarming increasing use of some fuels, such as gas and oil in the U.S.A. and the world.

There is too much discussion, feasibility studying, indecision, and delay being caused by groups who either are not aware of the problems they may be creating rather than solving or, seriously, it may intentionally be evolving from a plan of groups who want to create chaos in this country.

The engineers who understand these problems and the solution for the future of energy need to stand up and be heard at once. They need to say:

- Start off-shore drilling at once.
- Approve Northanna without any delay.
- Select the best transmission line routes and build them.
- Build the LNG Plant at Hampton Roads so we have an import center and are not dependent on only one pipe line from out west.
- Let's learn not to panic at oil spills. We long ago learned and still do clean up from floods, tornadoes, hurricanes, earthquakes, fires, you name it.

ROUTING PROBLEMS RELATED TO THE DESIGN OF URBAN STORM DRAIN SYSTEMS IN COASTAL AREAS. C.Y. Kuo. Dept. of Civil Engrg., Old Dominion Univ., Norfolk, Va. 23508.

Storm runoff volume has been increased due to the increase in impervious pavement areas as a result of urbanization. Detention basins are considered to be a widely accepted method to reduce the peak discharge of the flood. In the coastal urban areas such as Tidewater, the planning and design of the storm drainage system are significantly different from the mountainous and hilly areas. Special characteristics of the drainage system include (1) that a series of basins are connected by natural creeks or artificial canals, (2) that the delivery capacity of a canal is affected by the upstream and the downstream basins, (3) that the water elevation in a basin is related to the water level in the downstream basin, (4) that the outfall conditions is controlled by tides and currents.

Attempts have been made to consider the canals and basins as a system. A rational method for flow routing has been developed to aid the local consulting engineers. Assumptions, methodology, procedures, and example for routing in a system are presented.

IRRATIONALITY OF THE UNITED STATES ENERGY POLICY. C. Raphael, Pres., Atlantic Research Corp. Alexandria, Virginia 22314

Although the United States purports to recognize the significance of the worldwide and national energy problem, there has not been a national coherent definition, approach, or proposed solution to this problem. Formal reference is made to the "energy gap" between projected demand and supply, but the projected demand curves are incorrectly based upon extrapolation from the past rather than from consideration of economic and societal pressures and the limits of available resources. We speak of a national dedication to energy conservation while simultaneously encouraging the use of limited energy sources and imposing no restrictions upon the profligate use of energy other than that of encouraging all energy users to be a little bit uncomfortable. National and individual decisions are based upon economic analyses and price comparisons, but we then force these economic analyses into specific directions by fixing prices and assigning artificial values which are based upon past resources rather than consideration of future limitations.

This paper treats each of these elements of our weakly-defined energy policy and proposes that some real direction is necessary.

ENERGY-RELATED APPLICATIONS OF EARTH-PROBING RADAR WITH DATA ENHANCEMENT. W. L. Still\*, Aerospace Industrial Associates, Inc., L. A. Rubin\*, ENSCO, Inc.

Earth-probing radar has been used to detect geological structure and thin clay-filled fractures in hard rock to ranges in the order of forty-five to fifty feet. This was accomplished through the application of advanced data processing techniques. Without such processing, the effective range was in the order of ten to fifteen feet. Work has also been accomplished in coal mines to detect the interface between the coal and shale in the roof, as well as slip faults and stratigraphic structure above the roof. Other work has included measurements in coal to establish the feasibility of radar guidance of automated mining equipment. In each case, the results were greatly improved by application of computer processing techniques.

Potential energy-related applications of this work include: detection of fracture patterns in deep well geothermal fracturing, detection of dangerous roof, and potential methane barriers in support of mine safety, and increased coal productivity through machine automation and detection of hazards ahead of mining.

This work has been performed as a consultant to ENSCO, Inc. of Springfield, VA, and has been supported by NSF/RANN Grant #APR75-13414, the Bureau of Mines, and private companies.

REDUCED FUEL CONSUMPTION IN SMALL GAS TURBINE ENGINES BY USE OF CERAMIC COMPONENTS. E.F. McGOVERN\*, US Army Mobility Equipment R&D Command, Fort Belvoir, VA 22060

Increase in uncooled turbine inlet temperature in small gas turbine engines (mass flow less than 1 pound/sec) can result in significant increases in specific power output (hp per unit airflow) as well as associated reductions in fuel consumption.

Limitations of scale using very small components in these size engines may inhibit optimum match of cycle parameters (pressure ratio, operating speed and clearances) to achieve as high a percentage improvement in specific power and fuel consumption as might be anticipated in larger size turbine engine.

Characteristics of a very small (17 hp) gas turbine engine designed for Army ground electric power generation are described as a frame of reference to discuss ceramic component technology efforts currently underway or planned for small gas turbine engines.

Projected short and long range benefits of implementing ceramic components derived from these efforts in future small gas turbine engine designs are presented.

SIMULATING EFFECTS OF LAND USE CHANGE ON FLOOD HYDROGRAPHS GENERATED BY A FINITE ELEMENT METHOD. B. B. Ross\*, D. N. Contractor\*, and V. O. Shanholztz. Dept. of Civil Engineering and Agricultural Engineering, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

A numerical procedure is presented which deals with the problem of mathematical flood routing of overland flow and open channel flow. The finite element technique, using Galerkin's residual method, was used to solve the kinematic equations of one-dimensional transient flow in open channels. A one-dimensional finite element scheme was used to simulate overland flow over the watershed and open channel flow in the main streams, after a finite element grid had been devised for both the watershed and the streams. The effect of changes in the number and size of the elements in the grid was observed along with changes in the size of the time increment. Precipitation excess, the major input parameter, was obtained as a function of rainfall, depending on soil properties and existing land use across the watershed. The model was tested and calibrated on the South River watershed in Augusta County, Va., for the event of Hurricane Camille (August, 1969). The nature of the finite element procedure allowed changes in land use to be easily incorporated into the model. The effect of several arbitrary land use changes upon the response of the river under flood conditions was observed. (Aided by OWRP Grant A-062-VA)

THE ENGINEER - HIS DEVELOPMENT AND TRAINING IN INDUSTRY. G. J. Stoll\* and J. L. Hubbard\*. Babcock & Wilcox, Nuclear Power Generation Division, Lynchburg, Va. 24505

A discussion of the dual ladder concept of industrial career objectives for technical personnel, with a detailed plan for systemizing and planning technical training using all media, in-house, consultants, and university resources.

SYNTHESIS OF AN IMPROVED ERROR CORRECTOR/DETECTOR FOR HAMMING MINIMUM DISTANCE 4 CODE. M. R. Varanasi. Dept. of Electrical Engineering, Old Dominion University, Norfolk, Va. 23508

This paper presents an efficient technique of coding/decoding for the Hamming minimum distance 4 code. A similar code has been previously proposed by Hsiao which is more efficient from decoding point of view than the Hamming minimum distance 4 code, but loses the mechanization of the identification of error position. The code proposed here shall have all the advantages of the minimum odd weight column code proposed by Hsiao and in addition retains the advantage of easy identification of error position available in Hamming code.

In order to compare the complexity of encoding and decoding, an analysis has been conducted to estimate the decoding logic and decoding time required for each of the coding schemes. For the purpose of analysis different code lengths have been used and the results of the analysis are also presented along with the design of the encoder/decoder.

Index terms: minimum distance, odd weight column code.

## Section of Environmental Science

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

GAS FILTER CORRELATION RADIOMETER ANALYSIS Joseph Cases\* and Jacob Becher. Old Dominion University, Norfolk, Virginia 23508

The Gas Filter Correlation Radiometer (GFCR), in application to the remote sensing of trace gases in the atmosphere on a local, regional or even global basis, is potentially limited by the sensitivity of the measured upwelling thermal radiation to surface temperature and atmospheric temperature conditions. This study has been carried out to determine the merits of the concept, to examine the principles of operation of the GFCR and to obtain quantitative estimates of the errors produced in GFCR measurements of CO(4.6 $\mu$ ), SO<sub>2</sub>(8.6 $\mu$ ), NH<sub>3</sub>(11.0 $\mu$ ), and CH<sub>4</sub>(8.1 $\mu$ ) resulting from uncertainties in the atmospheric temperature profile and ground temperature. A simple mathematical prototype GFCR was assumed. A line-by-line atmospheric radiative transfer calculation was used to simulate the response of the instrument to varying concentrations of trace gases in several model atmospheres. Baseline results were calculated using the U.S. Standard 1962 Atmosphere and were then compared to results obtained using the other realistic models. These results reveal a very positive feasibility for application of the Gas Filter Correlation Radiometer technique to remote sensing of trace atmospheric gases and a direct need for such instrumentation for the purpose of obtaining more accurate information on atmospheric gaseous pollutants.

STUDIES OF URBAN HEAT ISLANDS FROM SPACE. K. P. Chopra, W. M. Prichard and L. W. Webb, Jr., Old Dominion University, Norfolk, Virginia 23508, and G. H. Trafford\*, NASA Wallops Flight Center, Wallops Island, Virginia 23337.

Cities act as heat islands and generate thermal anomalies on the micro- and macro- scales. These anomalies, typically around 6C, have a bearing on the local environmental quality and climatology. Therefore, an accurate knowledge of these effects is needed for better urban planning. The ground-based observations of urban heat island effects are often incomplete, tedious, not simultaneous and sometimes quite expensive. Studies with instrumented spacecraft have the potential advantage of providing sufficiently accurate, reliable and simultaneous data on the various environmental parameters covering a significantly large geographical area over a prolonged observational period. The TIROS, NIMBUS, NOAA and ERTS imagery data is utilized to provide evidence in support of the existing technical capability and its limitations, and the future potential for studies related to urban environment and planning.

DETERMINATION OF SURFACE TEMPERATURE FROM REMOTE RADIOMETRIC MEASUREMENTS: S. K. Gupta and S. N. Tiwari. School of Engineering, ODU, Norfolk, Va. 23508.

A simple procedure has been developed to infer the effective surface brightness temperature in the 4.6  $\mu$  CO fundamental band for water and/or land surfaces. The method involves the measurement of the total upwelling radiance over the spectral region of the band from a radiometer mounted on an aircraft and flown at tropospheric altitudes. Surface temperature retrieval is achieved by comparing the observed upwelling radiance computed for several surface temperatures using atmospheric radiative transfer model. Pressure, temperature and water vapor density profiles for the atmosphere are obtained from additional instruments on the aircraft and are used in the computation with the estimates of surface emittance and the concentrations of CO, CO<sub>2</sub>, and N<sub>2</sub>O. The sensitivity of the inferred surface temperature to uncertainties in a variety of surface, atmospheric, and experimental parameters (namely, surface emittance, atmospheric temperature and water vapor density profiles, CO concentration, and the altitude of observation) have been examined. It has been found that the uncertainties of surface emittance and water vapor density profile cause the greatest errors in the inferred value of surface temperature. CO concentration, atmospheric temperature profile, and the altitude of observation are the other factors in decreasing order of importance.

\*Supported by NASA Langley Res. Ctr. through Gr. No. NSG-1153

FILAMENTOUS GROWTH IN A HEAVY METALS MEDIUM WITH RELATIONSHIP TO ACTIVATED SLUDGE TREATMENT. Helen McWilliams, John W. Oliver\*, Van Note-Harvey Ass., Blacksburg, Va. 24060

Attempts were made to isolate and identify certain filamentous organisms found growing in activated sludge processes receiving high molecular weight ketones and heavy metals. It was observed that the organisms (identified as filamentous bacteria and fungi) grew on the surface of the water but underneath a layer of Methyl Isobutyl Ketone, commonly used in extraction procedures for certain metals by atomic absorption spectrometry, indicating that the organisms might be anaerobic or facultatively aerobic and the MBK served to extract metals for better assimilation by these organisms. Under microscopic examination, the organisms were seen to grow around flocs of metals.

A condition known as bulking is an extreme operational problem for activated sludge plants. Our laboratory has observed that occasionally slug doses of hydrocarbons from industrial sources has caused activated sludge plants to bulk or become filamentous. We have also observed that the filamentous growth, identified as being species of *Sphaerotilus* and *Nocardia* by other researchers, floats on the surface of the biomass in the aeration tank. On some occasions, levels of heavy metals during these conditions were extremely above normal. Due to these observations, it is postulated that a mixture of hydrocarbons and heavy metals in slug doses may sometimes be responsible for bulking in activated sludge.

THE USE OF SATELLITE WEATHER PICTURES AND SUNSPOTS TO MAKE LONG RANGE WEATHER FORECASTS. Boyd E. Quate, Boyd E. Quate & Associates, Suffolk, Virginia 23437.

A significant relationship between solar activity and the earth's weather patterns has been observed. Utilizing approximately sixty years of data a relationship between sunspot activity and the type, location and track of surface weather systems over North America has been identified. An important feature of this relationship is that there is an apparent time lag between the solar activity and the resultant weather patterns which can be utilized in making forecasts up to three months in advance.

Using weather satellite cloud pictures a test case of cloud cover at discreet locations as predicted by sunspots was made. A statistical test of significance was made to test the probability that 'No-Skil' was shown. In the case with similar sunspot numbers, the chance that 'No-Skil' was shown was less than 1/10th of 1 percent; whereas, in the case with the non-similar sunspot numbers the chance that 'No-Skil' was shown was greater than 50 percent.

Specific examples of both subjective and objective selections are given showing this relationship.

QUANTITATIVE MAPPING OF WATER QUALITY PARAMETERS IN THE JAMES RIVER, VIRGINIA BY AIRCRAFT REMOTE SENSING. Robert W. Johnson, NASA-Langley Research Center, Hampton, VA 23665.

Suspended sediment, chlorophyll *a* and other water quality parameters are important factors for monitoring water quality, water movement, and land use in river watersheds. Quantitative mapping of these water quality parameters from remotely sensed data provides synoptic information on levels and distributions not available by any other means. Stepwise regression analysis (SWRA) has been applied to quantitatively relate *in situ* measurements of parameters to remotely sensed multispectral scanner data. Regression equations from the statistical data analysis were used to synoptically map distributions of key water quality parameters - suspended sediment and chlorophyll *a* concentrations as well as a measure of water clarity, secchi disc depth. In addition, concentrations of a dissolved parameter, inorganic nitrate (NO<sub>3</sub>), were mapped due to high correlations with remotely sensed data and suspended sediment concentrations. Mappings of these four water quality parameters provided information on the flow and dispersion of a plume containing sewage treatment plant and industrial effluent.

A VISIBILITY CLASSIFICATION FOR MULTIPLE USE MANAGEMENT DECISION ON THE PHILPOTT RESERVOIR PROPERTIES. S. A. Nottingham, III\*, D. W. Smith\*, and R. E. Adams. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

As part of a comprehensive, computer-based, forest management plan for the government properties at the Philpott Reservoir, Virginia, the visibility of each 4-acre inventory-management unit was assessed to locate areas where intensive silviculture will have minimum visual impact on reservoir visitors. Visibility was determined by examining contour lines on U.S.G.S. 7.5 minute topographic maps and landform barriers on 1/12,000 stereo-pair, aerial photographs. Classifications were based on the degree of visibility from the reservoir, primary and secondary use areas, and roads.

A PRODUCTIVITY CLASSIFICATION FOR THE PHILPOTT RESERVOIR LANDS. C. W. Wade\*, R. E. Adams, and D. W. Smith\*. Dept. of Forestry and Forest Products, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

In order to manage forest land efficiently, relative growth potential must be assessed, and areas of uniform growth potential should be recognized.

Based on soil and topographic features, relative site productivity was classified for lands within the Philpott Reservoir complex located near Bassett, Virginia. The area was covered with a rectangular coordinate grid system in which each grid cell represented an area of four acres. Slope position, slope percent, and aspect were used in combination to classify each cell into one of five relative productivity classes. The productivity classes may be used to determine where silvicultural activities should be concentrated.

## Section of Geology

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

STRATIGRAPHY OF THE MT. PLEASANT FLATS AREA, VA. BEACH, VA.,  
L.D. Ames, J.W. Cross, J.B. Dischinger, J.M. Gilchrist and  
R.E. VanNieuwenhuse, Old Dominion University, Norfolk, Va.

Subsurface stratigraphic investigations in the Mt. Pleasant Flats area were conducted in conjunction with a multiple land-use study of the area. Data from thirteen 49 foot wells was obtained by using a split spoon drilling rig. Much sediment variability was found to exist both laterally and vertically making correlation on the basis of Oaks' and Coch's stratigraphic framework very difficult and tenuous.

The framework of Oaks and Coch consists of many "formations" for post Miocene time in our study area. Each "formation" has an extremely variable definition as to color, texture, structure and fossil content. Since our wells were confined to a five square mile area, we were able to some extent correlate lithologic units in adjacent wells by the physical parameters defined by Oaks and Coch. For those problem wells, we utilized the concept of cyclic sedimentation in which one cycle consists of a set of transgression-regression deposits that are controlled by the rise and fall of sea level associated with glacial waxing and waning. Our wells encountered the two most recent cycles of which each represents a formation. The older cycle is named the Talbot Formation, and the younger one the Princess Anne Formation. Once the larger time frame of a cycle was established, correlation of the lesser units corresponding to Oaks' and Coch's formations was made easier, even where sediment types were dissimilar.

BLUE RIDGE ANTICLINORIUM IN NORTHERN VIRGINIA.

James W. Clarke, U. S. Geological Survey, Reston, Va. 22092

The Blue Ridge anticlinorium in northern Virginia is a broad arch, which has a core of older Precambrian igneous and metamorphic rocks overlain unconformably by younger Precambrian clastic metasedimentary rocks of the Fauquier Formation of Furcron (1939) and metabasalt of the Catoctin Formation. As a result of detailed mapping in the Orlean quadrangle, a northeast-trending shear zone has been found within the older Precambrian rocks. East of this zone, the oldest rock of the core is an augen gneiss, which is similar to the so-called "Lovingston Gneiss" in central Virginia. This augen gneiss is intruded by the Marshall Granite of local usage. West of the shear zone, the oldest rock is the Flint Hill Gneiss, a biotite granitic gneiss; zircon from this rock yielded a concordant age of 1,081 m.y. Intrusive into Flint Hill Gneiss is the Robertson River Formation of Allen (1963), which has been dated by zircon at 730 m.y. Conglomeratic facies of the Fauquier or equivalents carry cobbles and boulders of all major units of the older Precambrian core rocks, including the 730 m.y. Robertson River Formation. However, the Fauquier is overlain by the Catoctin volcanics, which have been dated at 820 m.y. Thus, absolute ages of the Fauquier and Catoctin appear ambiguous on the basis of current information.

WAVE TANK STUDY OF SEDIMENT TRANSPORT. A. Ames and W. Felder, Department of Environmental Sciences, University of Virginia, Charlottesville, Va., 22903.

Measurements of volumetric sediment flux along subaqueous profiles in a laboratory wave tank, using uniformly grained material and under varying wave conditions. The measurements were made using time lapse photography, which proved to be a reliable, reproducible method providing a permanent record of experimental data. The magnitude of the net sediment transport at the end of 40 minute runs was found to be linearly dependent on original profile configuration alone, and was independent of wave parameters.

GROWTHOLOGICAL AND TOPOGRAPHICAL CONSIDERATIONS IN LAND-USE SURVEY OF MT. PLEASANT FLAT AREA, VIRGINIA BEACH, VA.  
J. W. Cross, R. E. VanNieuwenhuse, L. D. Ames, J. M. Gilchrist and J. Bender, Old Dominion University, Norfolk, Va.

Preliminary investigations of a land-use survey in the Mt. Pleasant Flats included an analysis of the topography and landforms included in the area. This information alone provided an insight into the drainage patterns, areas subject to flooding and runoff accumulation, and types of soil properties to be expected. Although relief in the Mt. Pleasant Flat is relatively unchanging over long distances, even slight elevation differences of a few feet dictate water movement across the surface of the land. The removal of the accumulated water from the area would be a very slow process, if the land was not modified, due to the nearly impervious nature of the local soil types. However, the extensive network of drainage ditches enhances water removal. Several drainage trends were discovered utilizing topographic maps. These trends were traced throughout the study area and could be used to estimate locations of areas needing extensive drainage networks before development, and the topographical survey was used in conjunction with the soil and water table analyses to obtain interrelationships of these physical properties of the Mt. Pleasant Flat as they apply to land-use surveys.

MINERALOGY OF A REVOLUTIONARY PERIOD IRON MINE AT NORTH GARDEN, ALBEMARLE COUNTY, VIRGINIA. T. W. Dagenhart, Jr.\*, G. L. Maddox\*, and R. S. Mitchell. Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903

The Albemarle Iron Works Company, founded in 1770, mined magnetic iron ore at the base of Cook's Mountain, west of North Garden, throughout the Revolutionary War period. For a short period after the Civil War another company worked the deposit. Titanium and phosphorus impurities limited the ore's utility somewhat but diversified the mineralogy of the deposit. Magnetite lenses are intimately associated with nelsonite-like rock (composed of ilmenite, apatite, and biotite) in the Lovington gneiss formation. The primary minerals within the deposit include magnetite, ilmenite, apatite, biotite, grunerite, hornblende, zircon, and garnet; the secondary minerals are crandallite, wavelite, churchite, smectite (nontronite?), anatase, and goethite. The minerals were identified primarily on the basis of their X-ray diffraction and optical properties.

CATION EXCHANGE CAPACITY OF JAMES RIVER SEDIMENT NEAR HOPEWELL, VIRGINIA, AND THE IMPLICATIONS FOR WATER POLLUTION. Dennis A. Darby, Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va., 23219.

The average cation exchange capacity (CEC) of the less than 2 $\mu$  size fraction of James River channel sediment is 31 meq./100g. There was no significant change in CEC after removal of organic matter by 30% H<sub>2</sub>O<sub>2</sub>. Either organics with high CEC are not abundant or more probably, exchange sites were blocked by iron which averaged 4 percent by weight of the channel sediment and 57 ppm of the interstitial water. After dredging into a confining sand dike, the average CEC of tidally suspended sediment at the dike outlet was 44 meq./100g with a standard deviation of 30. This was ten times the standard deviation of channel sediments. Variations in clay mineral contents and possible additions of high CEC organics account for the change in CEC. Due to the high Fe and Ca content, nearly all of the exchange sites were occupied by these elements. Thus, any significant metal transport in or out of the diked area must occur with the metal colloid or metal-organo complex. Supporting this are the extremely low concentrations of dissolved trace elements while particulate concentrations are much higher.

CHANGES IN JAMES RIVER SEDIMENT SIZE AND CLAY MINERALOGY UPON DREDGE DISPOSAL INTO A CONFINED DIKE. Dennis A. Darby, Dept. of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Va., 23518.

Approximately 167,000 m<sup>3</sup> of James River channel sediment 16 km downstream of Hopewell, Virginia was dredged and piped into a 396 m by 152 m confining sand dike within 10.5 days. Nearly 75 percent of the fine sediment (mean size of 4.8 $\mu$ ) piped into the dike flowed out through two outlet pipes approximately 350 m from the inlet pipe. The size and composition of the escaping sediment was unchanged from the incoming or channel sediment except that escaping sediment was bimodal instead of trimodal. Autosuspension within a mudflow or density flow would keep sand-size grains (up to 0.3 mm) in suspension from inlet to outlet pipes. Homogenous texture of sediment cores taken within the diked area support this type of flow during the dike filling. Within 3.5 months after the diked area was filled, tidal currents of up to 20 cm/sec were resuspending the unconsolidated sediment from this area. The suspended sediment was mostly unimodal, twice as fine-grained (mean size of 2.4 $\mu$ ) and more variable in clay mineral content than the original channel sediment. Despite the fine size, there was generally less smectite and vermiculite. These minerals were selectively removed, thus reducing the cation exchange capacity of the surficial sediment within the dike.

SEDIMENT SORPTION OF COMMON PETROCHEMICALS IN TWO ESTUARIES. D. A. Darby and P. Bowen\*. Department of Physics and Geophysical Sciences, Old Dominion University, Norfolk, Virginia.

The less than 62 micron size fraction of sediments from the James River, Virginia and the Arthur Kill, New York, were used in several experiments in order to determine the effects of common oils on flocculation and sediment sorption. The sediment consisted primarily of illite, chlorite and quartz in both estuaries. This sediment was mixed with either number 2 or number 4 oil in water of either 0.5‰ or 22.5‰ salinity. Temperature was maintained at about 10°C throughout. Flocculation was documented by 8mm motion pictures at 54 frames/sec, 18 frames/sec (normal speed) and 4 frames/sec. Samples with the heavier number 4 oil formed the largest flocs with settling velocities of about 3mm/sec. Samples mixed with higher salinity water always flocculated faster than sediment in 0.5‰ water. Yet, oil did induce flocculation in this lower salinity. In all cases where oil was added, a small amount of the sediment adhered to oil globules floating on the surface. Soxhlet extractions of the oil from sediment recovered from the bottom of the 2.5 liter settling tubes used in the experiments were analyzed by gas chromatograph and indicate that the sediment adsorbed approximately 2 microliters of oil per gram of sediment.

THE TAXONOMY AND PALEOECOLOGY OF PETALOCOCHUS FROM THE YORKTOWN FORMATION (LOWER FLOECENE) OF THE YORK-JAMES PENINSULA, VA. Cynthia E. Polson\*, Dept. of Geology, College of William and Mary, Williamsburg, Va. 23185

*Petalocochnus sculpturatus* (Lea), a sessile gastropod of the family Vermetidae, is reported from Floecene deposits of the Atlantic Coastal Plain and forms biostromes on the York-James Peninsula. This species is found in bio-fragmental sand and in association with a diverse, shallow marine assemblage containing very abundant *Amphistegina* lesions.

Specimens of *Petalocochnus* from the Yorktown and Duplin formations possess smooth, dextral nuclear whorls with 2 to 3 volutions. The early adult stage consists of 6 to 15 closely appressed whorls with longitudinal nodose ornamentation; internal laminae which radiate from the columellar wall, are usually present. Long, nearly straight to slightly curved, simple tubes characterize the late adult stage. *P. sculpturatus* forms radiating clusters or irregular masses and typically attaches to other mollusks. The linear tubes are oriented parallel to bedding and trend northwest.

The sessile vermetid gastropod found on the York-James Peninsula is assigned to the genus *Petalocochnus*, the subgenus *Petalocochnus* and the species *P. sculpturatus* on the basis of the external form, ornamentation, growth form and the presence of internal laminae. The biostrome was formed in a very shallow, possible littoral, marine environment.

STRATIGRAPHY AND STRUCTURE OF THE DRAPER MOUNTAIN AREA, PULASKI COUNTY, VIRGINIA. L.N. Ford, Jr.\*, W.F. Dula, Jr.\*, Dept. of Geological Sciences, Va. Polytechnic Inst. & State University, Blacksburg, Virginia, 24061.

The Draper Mountain area is 70 miles southwest of Roanoke, Virginia in Pulaski and Wythe Counties, Virginia. Draper Mountain is the overturned northwest limb of a doubly-plunging anticline. The area is a partial window (fenster) of Paleozoic rocks as young as Mississippian that are nearly surrounded by Cambrian rocks of the Pulaski and Max Meadows thrust sheets. The window is one of a series that extend from the Christiansburg anticline in Montgomery County, Virginia to the Kent window near Wytheville, Wythe County, Virginia.

The rocks of the Ordovician System imply deformation had begun at that time. By late Mississippian time the Pulaski and Max Meadows thrust sheets had been emplaced. Within the map area, the doubly-plunging nature of the rocks within the window and small-scale structures are evidence of cross-folding induced by a northeast-southwest component of force that began to be exerted prior to overthrusting.

The Crockett Knob complex, southeast of and parallel to Draper Mountain, consists of a pair of highly elongate, doubly-plunging synclines near the axis of the larger Draper Mountain anticline. On the southeast limb of this complex a normal fault runs the length of the structure.



SOIL AND SUBSURFACE CHARACTERISTICS PERTINENT TO LAND-USE SURVEY OF MT. PLEASANT FLAT AREA, VIRGINIA BEACH, VA. J.M. Glickchrist, L. D. Ambs, J. W. Cross, J. B. Dischinger and R. E. VanHousen, Old Dominion University, Norfolk, Va.

Several soil tests were performed on samples from a 5 sq. mile portion of the Mt. Pleasant Flats in conjunction with a land-use survey funded by the N.S.F. The soil was found to have a low to moderate liquid limit and moderate to high plasticity. A grain size study using pipette analysis and the Rapid Sediment Analyzer disclosed a soil profile consisting of a thin, silty A horizon followed by a very clayey B horizon extending from approximately 12" to 50", though the levels of transition varied between sites. A C horizon of relatively unaltered parent material generally began within reach of a hand auger. This material was sometimes of industrial quality. Motting, present to within a few inches of the surface, gave indications of a very high seasonal water table. The low slope of the area combined with slow vertical drainage due to the clayey B horizon resulted in standing water and instability of the soil after heavy rains.

These factors, when combined in a soil evaluation, point to farming as the most suitable use of this land, although other uses are feasible with alterations of the present conditions.

OCCURRENCE AND DISTRIBUTION OF FORAMINIFERA NEAR THE MOUTH OF THE CHESAPEAKE BAY, J. J. Harekity and R. S. Spencer, Old Dominion University, Norfolk, Va.

A total population study of recent foraminifera was made to correlate bathymetry, bottom sediment and average summer bottom salinity with summer foraminiferal occurrence in 21 sample sites in the lower Chesapeake Bay estuary. The study locations chosen were: (a) a series of ten sites oriented east to west at 37°44'N latitude and (b) a series of eleven sites spanning the mouth of the bay from Cape Henry to Fisherman's Island. Of the 85 species encountered, *Elphidium clavatum*, *E. subarticum* and *E. koebosense* were the dominant forms in the bay mouth and comprised as much as 96% 7% and 5% of the total population at each site, respectively. With the exception of only one site *E. clavatum* was the sole representative of its genus in the upper bay series. Here *Ammonia* species, *Elphidium* and *Ammonia* were the most consistent and dominant forms. *Ammonia* and *E. clavatum* comprised as much as 28% and 100% to the total population at each site, respectively. 72 species of foraminifera were encountered in the bay mouth, whereas only 12 species were observed in the upper bay series. Of the 5 parameters measured, the average summer bottom salinity and percent organic and mud content of the sediments seem to be primary differentiating factors between and within series.

GENETIC RELATIONSHIP BETWEEN INTERIOR BASINS AND MARGINAL GEOSYNCLINES. W. D. Lowry, Dept. of Geological Sciences, VPI & SU, Blacksburg, Virginia, 24061

Subsidence and sedimentation within the Appalachian, Cordilleran, Franklinian, East Greenland and (?) Ouachita geosynclines began in Proterozoic time and in places continued uninterrupted into Cambrian time whereas subsidence in interior basins did not begin until Cambrian time. The end of sedimentation in the interior basins of North America differs greatly in time and correlates well with the orogenic climax in the nearest geosyncline. Sedimentation in the Michigan and Illinois basins ended in Carboniferous time which marks the climax of orogeny in the Central and Southern Appalachians. The end of sedimentation in the Permian Basin correlates with the Marathon uplift of west Texas. The nearly continuous subsidence of the Williston Basin from Cambrian into early Tertiary time correlates with subsidence of the Alberta syncline, which was partially overridden by the Lewis overthrust in early Tertiary time. When geosynclinal collapse occurred as represented by major overthrusting, subsidence in the corresponding interior basin came to a close. This interplay between interior basins and marginal geosynclines reflects a crust capable of transmitting stresses great distances horizontally yet responsive to vertical motions that result in basins and arches.

EFFECT OF SCALE AND CRITICAL SLOPE ON IDENTIFICATION OF TOPOGRAPHIC FORMS. G. C. Grender, Dept. of Geological Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Terrain can be characterized as to shape or conformation through analysis of gridded arrays of elevations. By comparing the elevation of each point in the array with surrounding elevations, a computer program determines which of six basic shapes pertain to each point: Slope, Ridge, Valley, Knob, Sink or Saddle. Two factors strongly influence the determination: scale and critical slope. Scale has to do with the distance which elevations are compared, and critical slope (the minimum slope recognized by the program) is related to curvature of the topographic contours. The value of each must be explicitly set by the investigator. In general, slopes (surfaces without positive or negative reversals) are proportionately more abundant at smaller scales and larger critical slopes, whereas saddles are more abundant at larger scales and smaller critical slopes. Ridges and valleys tend to maximize at some combination of slope and scale that is a characteristic of the topographic "grain" of the area. The identification of knobs and sinks is complicated by the relationship between the topographic grain and the grid spacing. In short, the identification of topographic shape or form depends importantly upon the decisions as to minimum significant slope and scale of interest. Examples from areas in Virginia, Kentucky and West Virginia illustrate these relationships.

STRATIGRAPHIC AND PALEOENVIRONMENTAL ASPECTS OF THE MASSANUTTEN SANDSTONE, ROCKINGHAM COUNTY, VIRGINIA. J. S. Kite and W. P. Roberts, Madison College, Harrisonburg, Va. 22801

Thickness variations in late Ordovician and early Silurian sandstones of the central Shenandoah Valley are related to paleotopography. The upper Ordovician Oswego and Juniata Formations, over 1200 feet thick in Cove Mountain in the western portion of the study area, are absent in Massanutten Mountain to the east due to late Ordovician tectonic uplift and erosion.

The relatively thick (c. 650 feet) lower and middle Silurian Massanutten Sandstone, found only in Massanutten Mountain, was deposited in a synclinal trough, roughly parallel to the subsequent Massanutten Syncline. The absence of this trough is supported by north-northeasterly paleocurrent directions. The lower and middle Silurian Tuscarora and Clinton Formations, equivalents to the Massanutten Sandstone, are thinnest (c. 300 feet) in Little North Mountain in the western portion of the study area. This thinning exists due to the initial deformation in the area that was to become the Little North Mountain Anticline. Thickness variations and their relationship with existing folds indicate that deposition may have occurred syntectonically.

AN UNUSUAL OCCURRENCE OF DOLOMITE IN THE LIBERTY HALL FORMATION NEAR BLACKSBURG, VIRGINIA. Gregory R. Lumpkin\*, Dept. of Geological Sciences, Blacksburg, Virginia 24061

Recently discovered saccaroidal dolomite in a pelletal limestone facies of the predominantly black shales of the Liberty Hall Formation may help explain depositional environments in Middle Ordovician time.

Three irregular masses of dolomite occur 4 miles northeast of Blacksburg on a low ridge above the North Fork of the Roanoke River. The outcrops, which lie on the northwest limb of the Catawba Syncline, belong to the middle of the formation. They appear to be at approximately the same stratigraphic level and total separation along strike is approximately 1000 feet. The largest outcrop, which is no more than 10 feet in length, rises several feet above the enclosing, less resistant limestone.

Petrographic examination of the dolomite reveals relic pelletal texture, which indicates its derivation from contiguous pelletal limestone. A lowering of sea level may have provided an environment suitable for the concentration of magnesium in sea water. Also, shallow water conditions in a synclinal basin such as the Catawba syncline may have restricted circulation and promoted dolomitization.

The occurrence in the middle part of the Liberty Hall Formation of dolomite and the Diamond Hill conglomerates to the northeast indicates that depth conditions varied considerably during the depositional history of the Liberty Hall Formation.

## EVALUATION OF SEMIQUANTITATIVE CLAY MINERAL ANALYSIS.

M. Lyle\* and D. A. Darby, Old Dominion University, Norfolk, Virginia.

Several empirically derived methods of calculating clay mineral abundances from X-ray diffraction analysis are compared, including those by Biscaye (1965), Griffin (1971), Campbell (1973) and Darby (unpub.). The respective average standard deviations between clay mineral estimates using 73 mixtures of five standard clays and the clay percentages by weight for each of these five methods are: 24.5%, 23.3%, 27.2%, 25.6%, and 18.6%. Although Darby's method showed the smallest overall deviation from the standard weighted mixture, no method was consistently within 20% of the standards for any clay mineral. Biscaye's method was best for mixes containing only smectite and illite, while Schultz's method was best for mixes of these two minerals and kaolinite. Statistical analysis of the data indicate that comparisons between different methods cannot be mathematically compensated because of the variability in sample preparation and machine characteristics even when standard clay minerals are used. Variations in natural clay minerals and an undetermined inaccuracy to abundance determinations.

## IMPLICATIONS OF K/Ar AGE DETERMINATIONS IN NEW YORK AND NORTH CAROLINA ON THE CHRONOLOGY OF MOUNTAIN BUILDING IN VIRGINIA.

Douglas G. Moss, Department of Chemistry, George Mason University, Fairfax, Virginia 22030

The chronology of Precambrian and Paleozoic metamorphism in the Blue Ridge of the southern Appalachians and in the Reading and Manhattan Folds in the northern Appalachians has been studied by the U/Pb, Rb/Sr and K/Ar techniques. K/Ar data concerning the Precambrian event suggest that:

- 1a. there was only one thermal event at about 1100 m.y. ago, followed by continuous uplift and cooling, or
- 1b. there were two distinct thermal events at about 1100 m.y. and 900 m.y. ago.

K/Ar data concerning the Paleozoic event suggest that:

- 2a. there was only one thermal event at about 350-360 m.y. ago, or
- 2b. there was only one thermal event at about 440-470 m.y. ago, or
- 2c. there were two distinct thermal events at about 350-360 m.y. ago and about 440-470 m.y. ago.

Recent studies indicate that 1b and 2c appear correct.

VARIATION IN SHELL MORPHOLOGY OF THE FORAMINIFER, *Elphidium clavatum*, WITH RESPECT TO SALINITY, DEPTH, SEDIMENT TYPE AND ORGANIC CONTENT OF A PART OF THE CHESAPEAKE BAY. Pamela Kay Painter & R.S. Spencer, Old Dominion University, Norfolk, Va.

Twenty undisturbed specimens of *Elphidium clavatum* were studied from each of 9 stations in the Chesapeake Bay in order to determine variations in shell morphology and possible causes of the variations. The morphological characters measured were the diameter and radius of the test to the last chamber, the number of chambers and umbilical bosses, the number and average length of the retral processes on the last chamber and the degree of opaqueness of the test. These measured characters were compared using analysis of variance (SPSS statistical package) to the physical parameters mentioned in the title. There are significant differences at the 0.05 level between the 9 stations of all measured parameters except for sort and the average length of the retral processes. Opaqueness increases with increasing depth and mud content and decreasing grain size and salinity. A well-developed trend also occurs between decreasing numbers of retral processes and increasing mud content. Other general trends are noticeable but not as well-developed due to, apparently, the simultaneous interaction of several physical parameters with shell morphology. Decreasing diameter and radius of the test seem to be affected by increasing depth, mud content and decreasing grain size. The number of retral processes follow the same decreasing trend with decreasing grain size and salinity.

## COMPRESSION BOX GENESIS OF SECONDARY DRAG FOLDS-A STRUCTURAL DEFORMATION PROJECT. E. Victoria Pritchard,\* Dept. of Geol. Sciences, VPI&amp;SU, Blacksburg, Virginia 24061.

A glass-sided compression box was used to produce secondary drag folds. In this study a 2mm rubber gasket sheet, resting completely on sand, represented a basement complex with an initial synclinal configuration. Directly above the basement, layers of gypsum gapping plaster alternated with coarse sand beds, each 5mm thick and separated by very thin plastic sheets. Above these layers, whose aggregate thickness was 7 cm, a second 2mm rubber sheet was imposed in order to induce a shearing couple that would produce relative movement between the beds of sand and gypsum. As the beds were compressed in increments of 1 cm, secondary drag folds began to form.

Drag folds were produced as competent beds, here represented by the thin plastic sheets, arched up under lateral pressure. These supported the overlying rock, lessened the pressure on the underlying incompetent layers, and allowed flowage of incompetent material into the axial portions of the drag folds. "Drag" between the competent layers contributed to the production of these minor folds. A symmetrical pattern of drag folds developed on both limbs of the syncline with further shortening. Further experimentation should cast insight into conditions of formation of natural drag folds.

## GEOLOGY OF PLEISTOCENE DEPOSITS ALONG THE SOUTH BANK OF THE RAPPAHANNOCK RIVER NEAR WILTON, VA. Benjamin B. Smith\*, Dept. of Geology, College of William and Mary, Williamsburg, Va. 23185

Recent bank erosion along the Rappahannock River in Middlesex County, Va., has exposed a Plio-Pleistocene sequence of marine, fluvial-estuarine, and paludal deposits. Shelly sands of the Yorktown Formation underlie the entire area. The Norfolk Formation, which occurs east of the Suffolk scarp, is composed of a basal gray to tan, clayey sand, a lensoid peat body and an overlying bedded to massive, tan sand. The peat body, 4.5 m thick and 50 m wide, trends southwest and fills a valley cut into the underlying Yorktown and lower Norfolk Formation. The peat contains alternating layers of peat and organic rich clay, and large tree stumps. The peat and clayey sand have been planed and extensively burrowed near the top. The upper Norfolk consists of planar and cross-bedded, gravely to fine sands overlain by fine to medium, massive sands. The lower Norfolk clayey sand was presumably deposited during a Sangamon high-stand of the sea. Subsequently, a valley system was cut during a minor oscillation of sea level; marsh and swamp deposits later filled the valleys. As sea level continued to rise, the ancestral Rappahannock River planed the older sediments and deposited the bedded sands. The uppermost massive sands were deposited under nearshore marine conditions at the mouth of the ancestral Rappahannock River.

## SHALLOW DEPTH ELECTRICAL RESISTIVITY SOUNDINGS: THEIR APPLICATIONS IN THE MT. PLEASANT FLAT AREA, VIRGINIA BEACH, VA. R. E. VanNieuwenhuse, J. B. Dischinger, L. D. Amb, J. M. Gilchrist and J. W. Cross, Old Dominion University, Norfolk, Va. (sponsored by R. S. Spencer).

A multiple land-use study in the Mt. Pleasant Flats Area, Virginia Beach, Va. was conducted. Three of the physical parameters studied were: (1) depth to surface groundwater, (2) soil corrosion potentials, and (3) correlation of members and facies relationships in the study area.

Shallow-depth vertical electrical resistivity soundings were applied to investigate those three parameters in order to determine whether V.E.S.'s are a suitable means to study those parameters in a coastal plains environment.

Determination of corrosion potentials was the only successful application in this study. However, parastratigraphic beds determined by electrical resistivity were found to be correlatable between the several V.E.S. sites. Therefore, with the use of more controls, such as well-induction logs, shallow-depth V.E.S. may prove an effective means in the correlation of members and facies relationships in a coastal plains environment.

# Section of Materials Science

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

THE THINNING OF SILICON/SILICON OXIDE WAFERS FOR HIGH VOLTAGE ELECTRON MICROSCOPY. R. A. Bayles\* and W. A. Jesser. Dept. of Materials Science, Univ. of Virginia, Charlottesville, VA 22901.

Erratic electrical properties in FET devices made from silicon wafers coated with a silicon oxide layer have prompted an electron microscope study of the semiconductor/oxide interface. For this study 250  $\mu$  thick single crystal silicon wafers in (001) and (111) orientations with a 5000Å thick amorphous silicon oxide coating were obtained from NASA-Langley Research Center. Precise acid thinning through the silicon to the interfacial region was accomplished by using a backlit PVC mask which exposes only the silicon surface to the acid. In order to study the microstructural features of the thick oxide and the thinned silicon, high voltage electron microscopy and diffraction were employed. The wafers were observed to contain a low density of stacking faults, and 80  $\mu$  wide disc shaped regions of polycrystalline silicon. Irregularly shaped amorphous patches were also present.

Sponsorship under NASA Contract NAS1-12754-3 is gratefully acknowledged.

ADDITION OF TELLURIUM TO DENTAL ALLOYS. Alice C. Carwile\* and L. B. Johnson. Dept. of Materials Science, University of Va., Charlottesville, VA 22901.

Amalgams prepared from splat cooled alloys of Ag + 5% Te have previously been shown to have high strength and corrosion resistance but too much expansion during setting to be clinically useful alone. This research involved an effort to make use of the good qualities of the above alloy.

The splat cooled Ag + Te alloy powder was mixed with various amounts of splat cooled alloys in the Ag-Sn-Cu system. Amalgams were then prepared from these mixtures and tested for tensile strength, corrosion resistance and dimensional change during setting.

The best amalgams resulting from the above procedure had strengths better than 9000 psi, dimensional changes near zero and good corrosion resistance. These alloys may be useful dental restoratives. Therefore, further tests are being made to determine shelf lives. (Supported by NIH grant #DE 03965)

A STATISTICAL TREATMENT OF MICROSTRAIN UNDER COMBINED STRESSES. Stephen G. Cuppschalk, Dept. of Mechanical Engineering and Mechanics, Old Dominion University, Norfolk, VA 23508

A generalization of the Brown-Lukens dislocation theory of microstrain has been proposed such that the Schmid Law is explicitly applied to the cases of close-packed slip,  $\langle 110 \rangle$   $\langle 111 \rangle$  bcc slip, and single slip, and the combined stress situation has been treated. Results for a random grain orientation distribution are generally in good agreement with the von Mises criterion for the behavior of metals under combined stresses; however, in the present case, they depend upon grain size, slip geometry, and dislocation substructure.

STANDARD CORROSION TEST FOR DENTAL AMALGAM. Craig Davidson\* and G. E. Stoner\*. Dept. of Materials Science, Univ. of Virginia, Charlottesville, VA 22901.

Corrosion of dental amalgam occurs via an electrochemical mechanism. There exist on the surface of the amalgam anodic and cathodic sites due to the galvanic action of the phases present and the differential aeration of the amalgam as a whole. Congo Red indicator dye has been found to adsorb on the cathodic sites (or phases), yielding a "map" of these areas. On any given amalgam, the more dye adsorbed the greater the ratio of anodic to cathodic current densities with a correspondingly higher rate of corrosion.

By investigating the behavior of the dye on amalgam surfaces over the potential regions of interest and calibrating this behavior against differential aeration and anodic polarization studies, a standard corrosion test has been developed which will produce results in less than 24 hours. This test can be used to screen dental amalgams and aid in their subsequent laboratory evaluation.

ULTRASONIC ATTENUATION IN THIN SPECIMENS. D. T. Hayford\* and E. G. Henneke, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Traditionally, ultrasonic attenuation in thin specimens has been difficult, if not impossible, to measure accurately by the pulse-echo technique. This difficulty can be traced to many causes; but the primary reason is that the original pulse width is much longer than the travel time in the specimen, so that the returning echoes are lost in the input pulse. This difficulty can be eliminated by use of a buffer block to delay the returning echoes, but this solution has other problems. Among these are improper impedance matching between specimen and buffer, bond losses, and an input pulse with a relatively slow rise time. The latter reduces the applicability of techniques suggested by others in the field. This paper deals with these problems and suggests a new method of measuring ultrasonic attenuation in thin specimens.

FIBER REINFORCED DENTAL COMPOSITES. O. C. Hodgins\* and F. E. Wawner. Dept. of Materials Science, Univ. of Virginia, Charlottesville, Va. 22901.

Commercially available dental composite restoratives are typically composed of an epoxy-methacrylate type resin reinforced with glass spheres. Glass is used as the reinforcing medium because of its favorable index of refraction, rendering the final composite esthetically pleasing. Conventional composites suffer from relatively low strength but more importantly from poor abrasion resistance in the oral environment because of low surface area of the spheres and hence poor bonding. Because of this, a study has been conducted to improve the mechanical properties of dental composite restoratives by using different shaped reinforcements.

In this study glass fibers were utilized, either in the form of individual fibers or as woven glass cloth. The samples were prepared such that the fibers were in random orientation (individual fibers) and in preferred orientation (cloth).

Results are presented for the diametral tensile strength and abrasion resistance of these samples for comparison with a commercial composite.

SIMULATION OF THE FUSION REACTOR ENVIRONMENT WITH AN ION ACCELERATOR AND AN HVEM. J. A. Horton\* and W. A. Jesser. Dept. of Materials Science, Univ. of Virginia, Charlottesville, Va. 22901.

The first wall of the controlled thermonuclear reactor will be subjected to an intense flux of high energy neutrons and charged particles. An effective simulation of this environment may be performed by using the ion accelerator to supply high energy ions and the electron beam of the HVEM to vary the damage production to ion deposition rate. The modifications and techniques necessary to allow the simultaneous impingement of the ion and electron beams on the sample are discussed. Results of initial experiments performed on stainless steel type 316, the presently expected prototype first wall material, are also reported.

We gratefully thank the Energy Research and Development Administration for financial sponsorship.

THERMOGRAPHIC DEFLECTION OF DAMAGED REGIONS IN COMPOSITES. T. S. Jones\* and E. G. Henneke, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

Due to the nonhomogeneous nature and unusual failure modes of advanced fiber reinforced composite materials, conventional non-destructive testing techniques are difficult to apply and to interpret when used on these materials. Because of the increasing use of advanced composites and quality control problems, effective NDT methods for composite materials are in great demand. We are, therefore, currently engaged in investigating the possible applicability of new, unusual NDT methods for composites.

The approach to be reported here has been to set up high frequency vibrations in a fiber reinforced composite specimen of symmetric lay-up. When the resulting elastic waves in the specimen encounter a flaw or a damaged region, a differentiation of scattering characteristics occurs. The effect of this scattering is measured as a temperature rise at the damage site. This temperature rise is monitored and recorded using a thermographic camera.

THE EFFECT OF INITIAL DAMAGE IN FATIGUE PROPERTIES OF BORON/ALUMINUM COMPOSITES. M. A. Knott\*, Dept. of Engr. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061.

Two groups of boron/aluminum (B/Al) laminated composite plates are compared to each other. One group contains surface and interior defects caused by manufacturing processes, while the other is relatively damage free.

Various non-destructive techniques (NDT) including, vibration signatures, C-scan and X-ray tests, were coupled with fatigue experiments to make the evaluations. The utilization of forced longitudinal vibration tests is a particularly promising method for evaluating material property changes (i.e. stiffness and damping characteristics).

The specimens were fatigued at various test levels, with vibration signatures and other material information taken after the completion of a set number of cycles. The data was analyzed to establish the effect of initial damage on the fatigue properties of B/Al composites.

MICROSTRUCTURE AND MECHANICAL PROPERTIES OF SCHLADITZ POLYCRYSTALLINE IRON WHISKERS. D. Lashore\*, W. A. Jesser, H. Schladitz\*, and H. G. F. Wilsdorf. Dept. of Materials Science Univ. of Virginia, Charlottesville, Va. 22901.

The microstructural characteristics and some of the mechanical properties of the iron whiskers produced by the Schladitz technique are described. The microstructure can be subdivided into three distinct regions. The core region is called the primary structure which acts as a foundation upon which a series of concentric rings, the secondary structure, forms. The secondary structure is made up of particles of a nominal 1000 Å diameter. A region near and including the outer surface constitutes the third region and is thought to consist of Fe<sub>2</sub>O<sub>3</sub>. Both X-ray and high voltage electron microscopy indicate a grain size of from 50 to 200 Å. The extremely high, diameter-independent tensile strength was measured to be 874,000 psi and is thought to be due to this small grain size.

We gratefully appreciate sponsorship under ONR contract #N 00014-75-C-0691

ON THE CARIES PROCESS IN ENAMEL. A. F. Marshall and K. R. Lawless, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901.

The early caries lesion is a result of subsurface mineral dissolution in the enamel by acids produced in the mouth. The caries process follows structural elements in the enamel particularly the enamel rods and the striae of Retzius. The structural breakdown has been examined in the polarizing light microscope, SEM and TEM. Although there is some ambiguity in the observations, it has been found that caries produces a gap at the rod junctions followed by preferential loss of the rod cores. The hydroxyapatite crystallites within the rod decay preferentially at their core along their c-axis.

In order to study the process with more control it is desirable to simulate caries *in vitro*. This has been done with an acid buffer system to which an organic component is added. This results in a lesion with an intact surface and the desired structural breakdowns.

THE USE OF TWO DIMENSIONAL REINFORCEMENTS IN DENTAL COMPOSITES. Gerrit Stafford and F. E. Warner, Dept. of Materials Science, Univ. of Virginia, Charlottesville, VA 22901.

In order to improve the strength and abrasion resistance of polymeric resins, various shapes and sizes of glass particles have been added to the resin. The purpose of the resin matrix is to transfer and distribute an applied load to the stronger glass filler. In order for this to be effective the glass should have the ability to carry the load in at least two dimensions. Flakes with length/thickness ratios in excess of 100 can be considered two dimensional particles. These particles when oriented in a laminar fashion can carry the load quite well. Diametral tensile strength increases of 140% have been noted for composite samples with laminar orientation of the flakes as compared to samples with flakes oriented parallel to the longitudinal axis of the sample.

Since flakes have a high surface to volume ratio, the laminar orientation should also give high abrasion resistance. The lack of abrasion resistance has been the shortcoming of most dental composites currently in use.

The following three areas of study will be presented:

- 1) The development of an effective silane coupling agent to encourage bonding at the glass/resin interface, 2) The effect of monomer composition on its viscosity and resin strength, 3) The use of ultrasonic and centrifuging techniques in order to get desired orientation and loading.

EFFECTS OF MATERIAL NONUNIFORMITY IN LMFB ENVIRONMENTS ON MECHANICAL RESPONSE. Gansen Subbaraman\*, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061

Impurity contents in stainless steels have been found to vary in Sodium environments due to thermo-chemical interactions. Such variations influence the mechanical properties and response to stresses and internal pressures of clad alloys used in LMFBs. In the present work, a generalized continuous function,  $f(r)$ , is introduced to accommodate radial property variations of the clad in the constitutive equations of stress equilibrium. The displacement and the stress-strain values are then evaluated for specific analytical representations of  $f(r)$  which result in closed-form and analytical solutions to the differential equations of equilibrium. An adjustable constant,  $A$ , used in  $f(r)$  enables strong variation of the elastic parameters of the material to be affected representing severe property degradations which can be studied by varying  $A$  accordingly.

SOME RESPONSE CHARACTERISTICS OF SMALL FLAWS. Ahmet Talug\*, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061

In the present work, finite element and boundary point collocation techniques are employed in investigating the distribution of stresses in the immediate vicinity of the crack tip for single edge cracked specimens containing cracks of vanishingly small size.

Stress fields obtained by a plane stress finite element model are compared with those obtained by boundary collocation the Williams stress function. It is shown that since the single parameter approach can adequately represent the stresses only within a vanishingly small region for small cracks, a multiparameter approach becomes a more precise alternative for stress analysis involving crack initiation processes.

DENTAL AMALGAM STABILIZATION BY SELECTIVE INTERFACIAL AMALGAMATION. L. D. Zardnickas\*, G. E. Stoner\*, and F. K. Smith. Dept. of Materials Science, Univ. of Virginia, Charlottesville, VA 22901.

Dental amalgam is the most successful of all biomaterials. In spite of this success, failure of amalgam *in vivo* does occur. This failure may be attributed to corrosion of the  $\gamma_2$  ( $\text{Sn}_7\text{-Hg}$ ) phase of dental amalgam by a process of differential aeration. The purpose of this investigation was to explore the feasibility of enhancing the stability of dental amalgam restorations by a process of "selective interfacial amalgamation". If dental amalgam restorations can be selectively alloyed at the tooth amalgam interface, to a minor thickness as compared to the dimensions of the bulk amalgam, so as to present a more electrochemically stable phase than  $\gamma_2$  to the oral environment, corrosion will be reduced and desirable qualities of existing amalgams can be utilized.

Experiments were conducted to determine the feasibility of selective interfacial amalgamation, to determine if tin would be excluded from the surface restorations. Results showed the process to be feasible. Results of both X-ray diffraction and X-ray energy analysis showed the absence of both  $\gamma_2$  and tin at the surface and little or no penetration of Sn into the selectively alloyed layer. Scanning electron microscopy and optical metallography showed the continuity of the bond between the  $\gamma_1$  layer formed and bulk amalgam.

STRAIN GAGE READINGS ON COMPOSITE MATERIALS. C. B. Zeitan\*, W. K. Stinchcomb, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst., Blacksburg, Va. 24061

Composite materials are increasing in use in many structural applications. Therefore it is necessary to have reliable measurements of mechanical properties. Young's Modulus is one of the more significant of these properties. In order to determine Young's Modulus, strain gage measurements are frequently necessary. However, a problem of heat build-up in gages on composite materials has been detected and faulty readings have resulted.

The search for a solution to the problem has centered on an investigation of the heat build-up using thermographic techniques associated with modifications in current input and gage characteristics.

## Section of Medical Sciences

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

A PROJECTOR ILLUMINATED COMMUNICATION (PIC) BOARD, J. A. Allaire\*, L. K. Vogtle\*, P. A. Allaire\*, Dept. of Pediatrics, Univ. of Va., Charlottesville, Va. 22901

Some neurologically impaired children lack the motor coordination necessary to attain oral speech yet they possess adequate comprehension skills. Communication boards often provide the only means of expression for these nonoral children. A Projector Illuminated Communication (PIC) System has been constructed utilizing an automatic carousel slide projector with a rear projection screen. The system has two major advantages: low cost and large memory capacity. Cost of the PIC Board is under \$500 which is well below the \$2000 for most other commercially available boards. The memory capacity of up to 14,000 pictures and/or words/symbols is easily accessible using the automatic slide advance. Several prototypes have been designed, constructed and used by nonoral children.

ETHYLENEDIAMINE INTERACTION WITH METHYLGLYOXAL AND GLUTATHIONE. Richard Brandt and Ronald Gup\*, Dept. of Biochemistry, Med. Col. of Va., Richmond, Va. 23298

Methylglyoxal (MeG), an  $\alpha,\beta$ -dicarbonyl with its cofactor glutathione (GSH), form the substrate for the enzyme glyoxalase I. Testing various diamines as potential inhibitors of glyoxalase I, it was found that when MeG and GSH were treated with ethylenediamine (EDA), there was a rapid decrease in the apparent concentration of MeG. The procedure used for methylglyoxal determination was the 2,4-dinitrophenylhydrazine method developed by Gilbert and Brandt (*Anal. Chem.*, **47**, 2418, 1975). With the rapid decrease in [MeG] a transient pink colored product was formed only in the presence of GSH and EDA. Maximum absorbance was found at 494 nm at pH 6.8 in phosphate 0.10M buffer. Of the aliphatic diamines tested, 1,3-propanediamine, 1,4-butanediamine, spermine, spermidine and EDA, only EDA demonstrated color formation. It has occurred to us that this finding could be used for the quantitative determination of GSH. Using a Gilford recording spectrophotometer the absorbance at 494 nm of varying concentrations of GSH from 1 to  $7 \times 10^{-5}$ M was determined using  $3 \times 10^{-3}$ M solutions of EDA and MeG. Maximum absorbance proportional to the glutathione concentration developed at 25°C in 5 to 6 min. This analysis for GSH will be applied to tissue homogenates and serum.

IN VIVO AND IN VITRO BACTERIOSTATIC OF STAPHYLOCOCCUS AUREUS ON STAINLESS STEEL PINS COATED WITH ELECTROLYZED SILVER OR SILVER STEARATE. G. Colmano and S.S. Edwards, Dept. Vet. Sci., VPI & SU, Blacksburg, VA 24061

Pins, 1.57 mm diameter and 2.5 cm<sup>2</sup> surface area, were prepared: (1) solid Ag, (2) stainless steel = ss, (3) ss Ag electroplated, (4) ss Ag electroplated chloridized, (5) ss coated with a saturated solution of Ag stearate, (6) ss with 50 double layers of Ag stearate. Sets of 3 pins of each type were contaminated with  $10^6$ - $10^7$  Staph. a., inserted in tryptose blood agar and also in brain heart infusion agar plates, and connected to 10  $\mu$ AH/cm<sup>2</sup> DC current, with one pin negative, one positive, and one unconnected control. The following effects were observed: (a) Current fluctuation (resistance increased in Ag and Ag electroplated, and decreased in ss and ss Ag stearate coated pins); (b) Clear halo formation in blood agar, most pronounced around the solid positive Ag and the Ag electroplated pins (the RBC content within the halo and the rest of the plate remained constant, while the HB decreased by 1/3 within the halo); (c) Oxidation of the positive solid Ag, ss Ag electroplated, and ss Ag electroplated chloridized pins only; (d) Inhibition by current of bacteria on orthopedic intramedullary pins *in vivo* and on pins of the same material in the plates *in vitro*, which indicated that bacteriostasis increased with positive current to ss Ag stearate pins *in vivo*, and also increased with decreasing resistance of the electrodes *in vitro*.

Nuclear Envelope Polypeptides: Determination of their Disposition by Protein Cross-linking Probes. D. L. Cochran\* and K. R. Shelton, Department of Biochemistry, Medical College of Virginia, Richmond, Virginia 23298

A nuclear membrane fraction has been isolated from chicken erythrocytes. Several cross-linking reagents have been used to examine the spatial relationship of the various major polypeptides in the nuclear envelope fraction. Two bifunctional cross-linking reagents, dimethyl suberimide dihydrochloride and dimethyl adipimide dihydrochloride, have been used as well as methyl-4-mercapto-butylrimide dihydrochloride, a cleavable cross-linking reagent. The results were examined after separation of polypeptides by electrophoresis on sodium dodecyl sulfate polyacrylamide gels. The results indicate that all the major polypeptides are cross-linked by dimethyl adipimide dihydrochloride. However, dimethyl suberimide dihydrochloride selectively crosslinks a major peak of approximately 77,000 molecular weight. Selective cross-linking of this major peak results in the production of high molecular weight polypeptides. Similar results are obtained with methyl-4-mercapto-butylrimide dihydrochloride. Cleavage of this cross-linking reagent results in a normal distribution of polypeptides. The results suggest that protein-protein interactions may play a vital role in nuclear envelope structure.

# ALTERATIONS IN HEPATIC TRIGLYCERIDE LEVELS FOLLOWING ISONIAZID TREATMENT. S. L. Dudley\* and W. L. Banks, Jr., Dept. of Biochem., Med. Coll. of Va. (VCU), Richmond, Va. 23298.

Hepatic and serum lipid parameters were determined at 0, 2, 12, 24 and 36 hrs. following a single intraperitoneal injection (150 mg/kg body weight) of isoniazid (INH) or saline to groups of male albino rats. During this time period, a biphasic alteration in hepatic triglyceride levels occurred with elevations at 2 and 24 hrs. returning to control levels at 12 and 36 hrs. following INH treatment. The 2 hr. increase in hepatic triglyceride concentration was concomitant with elevated levels of serum free fatty acids which may be associated with fatty acid mobilization from adipose tissue. The subsequent 24 hr. hepatic triglyceride increase correlated with increased serum triglyceride levels but not with elevated serum free fatty acid levels. Studies of the dextran sulfate-calcium chloride precipitable fraction of the serum lipoproteins over the 36 hr. period revealed that this fraction of lipoproteins did not decrease in concentration at 2 or 12 hrs. and were elevated both in triglyceride and protein contents at 24 hrs. in the INH treated animals. Since the major function of this fraction of lipoproteins is transport of triglycerides from the liver, the data would suggest that the elevated hepatic triglyceride levels at 2 and 24 hrs. was probably not due to a drug-related block in the transport of triglyceride from the liver. (Aided by NIH grant CA 15615)

# THE SEARCH FOR MAGNETIC SENSORS IN MAN. Z.V. Harvalik, 5901 River Drive, Lorton, VA, 22079.

It has been observed that so-called dowsing signals can be obtained when a dowser is exposed to artificial magnetic or electromagnetic fields<sup>1</sup>. Is his body shielded with a heavy aluminum foil no dowsing signal occurs when the foil covers the kidney area while the dowser walks across a high frequency beam of low intensity. More detailed measurements suggest that magnetic sensors exist in man probably located in the vicinity of the renal glands. Extinction of the dowsing signal is also observed when the head of the dowser is shielded with an aluminum foil positioned around the head like a "crown". This would indicate the presence of an additional sensor in the brain. Since programming for specific patterns of magnetic disturbances (signatures) has been obtained by many dowsers it is believed that the brain also contains a signature processor. The location of the sensor-processor seems to be in the vicinity of the pineal gland. This processor transmits to the arms the command to twist. This twist can be made better visible by using the dowsing rod which acts as a parametric amplifier. Medical, including diagnostic implications of above-reported phenomena will be discussed.

<sup>1</sup> Z.V. Harvalik, Virginia Journal of Science, 21, 59, (1970)

# HEPATIC INORGANIC PYROPHOSPHATASE ACTIVITY FOLLOWING HYDRAZINE TREATMENT TO RATS. P. D. Henson, G. K. Harrington\*, S. H. Banks\*, and W. L. Banks, Jr., Dept. of Biochem. and MCV/VCU Cancer Center, Med. Coll. of Va. (VCU), Richmond, Va. 23298 and Dept. of Chem., Roanoke College, Salem, Va. 24153

Male albino rats were injected with neutralized hydrazine (40 mg/kg body wt., i.p.) and sacrificed at 4 and 24 h after drug treatment. Their livers were removed, homogenates prepared, and DNA and protein concentrations determined. A 3000 x g supernatant fraction was employed for the pyrophosphatase assay which involved a spectrophotometric analysis of the formation of inorganic phosphate from added inorganic pyrophosphate. Liver weight and total protein content were significantly elevated at 24 hrs following drug treatment but inorganic pyrophosphatase activity, when viewed on a mg protein, mg wet liver, or mg DNA basis, remained essentially unchanged compared to controls at both time points.

The general lack of sensitivity of this enzyme to hydrazine was confirmed in *in vitro* studies using yeast inorganic pyrophosphatase. Concentrations of hydrazine 500 to 1000 times greater than substrate concentrations were required before inhibitory effects were observed. Since the hydrazine concentrations employed in *VXKX* far exceeded those known to produce *in vivo* changes in metabolic parameters related to hepatic hypertrophy, it is concluded that hepatic pyrophosphatase probably does not play an active role in liver proliferation induced by hydrazine treatment. (Aided by NIH grant - CA 15615).

# INTRACELLULAR CRYSTALLINE DEPOSITS FORMED BY BACTERIA;

William E. Keefe, Ph.D., Department of Microbiology, Medical College of Virginia, Virginia Commonwealth University, Richmond, Va. 23298

Several species of bacteria were found to form calcium containing crystalline materials when grown in a defined culture medium as well as in urine obtained from a kidney stone former and a non kidney stone former. In some instances the type of crystalline material formed by a bacterial species was dependent on the type of medium in which the bacteria was cultured. Several of these bacteria have been isolated from the kidneys of patients with kidney stones indicating that microorganisms may be involved in the nucleation process of kidney stone formation.

# IMMUNOSUPPRESSIVE EFFECTS OF 8,9-EPOXY-HEXAHYDROCARBONOL (EHHC), P.C. KLYKKEN\*, S.H. Smith\* and A. E. Munson\*, Devey (Sponsor), Dept. of Pharmacology and the MCV/VCU Cancer Center, Med. Coll. of Va., Richmond, Va. 23298

EHHC treated-mice showed a dose dependent inhibition of both humoral and cell mediated immunity. The hemolytic plaque forming assay was employed to determine both the IgM and IgG antibody response. BDF<sub>1</sub> male mice were given 4x10<sup>8</sup> sheep erythrocytes i.p. followed 24 and 48 hrs. later by i.p. injections of EHHC for the IgM determination. EHHC produced a dose dependent inhibition of plaque forming cells (PFC)/10<sup>6</sup> spleen cells and PFC/spleen on days 3, 4 and 5 after antigen. On day 4 the ED<sub>50</sub> for PFC/10<sup>6</sup> spleen cells and PFC/spleen was 28 and 18 mg/kg, respectively. Peak response to IgG antibody production was seen on day 9. EHHC (100 mg/kg) administered i.p. 48 hrs. post antigen produced a 58% and 46% suppression of PFC/10<sup>6</sup> on days 7 and 9 respectively. EHHC was also tested for its ability to inhibit delayed type hypersensitivity (DTH). CD<sub>1</sub> male mice received 100 ug C. parvum in the left footpad. Two days after sensitization EHHC was administered in doses of 0.78-50 mg/kg i.p. A challenge dose of 100 ug C. parvum was injected into the right footpad on day 6 and footpad swelling was measured 24 hrs. later by mercury displacement. EHHC at a dose of 0.78 mg/kg produced a 95% inhibition of the DTH response. These and previous studies suggest that EHHC primarily inhibits T lymphocytes. Supported in part by USPH grants DA1312, CA17551, and IT26W07111.

# QUANTITATIVE HISTOCHEMISTRY OF NEOPLASIA IN THE HUMAN BREAST. E. H. Lerner\* and Charles L. Rutherford, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061.

Alterations in tissue specific metabolism can be quantitatively evaluated for cell types within any given tissue by means of an ultramicrochemical technique in association with routine histological examination. Frozen specimens are sectioned for staining or lyophilization in alternating sequence, then compared microscopically. By tandem observation the position of heavily invaded areas can be dissected from the experimental tissue sections in preparation for enzymatic analysis. It has thus been possible to compare the activities of the following enzymes within malignant and benign breast lesions as well as lactating bovine mammary gland: lactic dehydrogenase, phosphoglucose isomerase, pyruvate kinase, glucose 6 phosphate dehydrogenase, hexokinase, glycerol phosphate dehydrogenase, and phosphofructokinase. The resultant overview of cell specific metabolic events underlines an anaerobic potential on the part of malignant tissue: a high activity of lactic dehydrogenase is maintained in the milieu of a reduced capacity for a glycerol phosphate dehydrogenase - mediated respiratory shunt.

STRUCTURE-IMMUNOSUPPRESSIVE ACTIVITY OF CANNABINOIDS, A. E. Munson<sup>1</sup>, J. M. Teager<sup>2</sup>, and J. A. Levy<sup>3</sup>, W. Dewey (Sponsor), Dept. of Pharmacology and the MCW/VCU Cancer Center Med. Col. of Va., Richmond, Va. 23298

Previous studies reported that  $\Delta^9$ -tetrahydrocannabinol ( $\Delta^9$ -THC) inhibits cellular and humoral immunity. We determined the activity of six additional cannabinoids *in vivo* against sheep erythrocyte (sRBC) plaque-forming cells (PFC) and *in vitro* against phytohemagglutinin (PHA) mediated lymphocyte stimulation. Drugs were administered i.p. 2 days after antigen and PFC determined 4 days after antigen. The ED<sub>50</sub> calculations are based on day 4 which is the peak response day.  $\Delta^9$ -THC gave an ED<sub>50</sub> of 70 mg/kg in the PFC assay and an IC<sub>50</sub> of 9  $\mu$ M in the PHA stimulated lymphocyte study. Hydroxylation of the 11 position of  $\Delta^9$ -THC slightly decreased the ED<sub>50</sub> to 50 mg/kg.  $\Delta^8$ -THC was 4.7 times more potent than  $\Delta^9$ -THC giving an ED<sub>50</sub> of 15 mg/kg but was slightly less active against the PHA stimulated lymphocyte (IC<sub>50</sub>=11.5  $\mu$ M). 11 methoxy  $\Delta^8$ -THC was less active than  $\Delta^8$ -THC giving an ED<sub>50</sub> of 38 mg/kg. Cannabinol was equipotent to  $\Delta^8$ -THC against the PHA stimulated lymphocyte (IC<sub>50</sub>=8.5  $\mu$ M) but gave highly variable results in the PFC assay (ED<sub>50</sub>=100 mg/kg). Cannabinol was inactive in the PFC assay but showed an IC<sub>50</sub> of 5.3  $\mu$ M against the PHA stimulated lymphocyte. Olivital was inactive in the PFC assay. These studies show some of the structural requirements of the cannabinoid nucleus for immunosuppressive activity. Supported in part by grants USPH DA1312, CA17551, and IT326M97111.

THE EFFECTS OF SHORT-TERM NICOTINE WITHDRAWAL ON DAY VIGILANCE AS MEASURED ELECTROPHYSIOLOGICALLY, L.C. Parsons, Nancy Bell<sup>1</sup>, Linda Comer<sup>2</sup>, Ann Swartz<sup>3</sup>, and Casey Weissenborn<sup>4</sup>, Sch. of Nursing and Dept. of Physiology, Sch. of Medicine, Univ. of Va., Charlottesville, Va. 22903

Electrophysiological measurements were taken on 5 adult females who were habitual smokers, ranging in age between 20 and 50 years. Recordings were made at prescribed time intervals for the purpose of determining the effect of 24 hr. nicotine withdrawal on the level of vigilance during the normal waking hours. Following electrode placement (EEG, ECG, EKG, and PCRS, and Respiration) each subject was continuously video and electrophysiologically monitored for a period of 60 minutes for 4 consecutive days. Day 1 served as a conditioning day; day 2 control day; W<sub>1</sub> nicotine withdrawal day; and R<sub>1</sub> recovery day or return to smoking. All subjects showed decreases in heart rate (HR) and respiratory rates (RR) on W<sub>1</sub> when compared to control or R<sub>1</sub> days. EEG patterns showed a progressive increase in mean total sleep time from control to R<sub>1</sub> in subjects between the ages of 20 and 22 yrs.; while older subjects, 36-50 yrs. showed an increase in total sleep time on R<sub>1</sub> rather than W<sub>1</sub> probably because the R<sub>1</sub> period of recording was made in the morning before sufficient quantity of nicotine had been consumed following the 24 hr. withdrawal period. The PCRS tended to correlate very closely with the EEG level or stage of vigilance. (Aided by NIH Grants RO-2-NU-00345-06 and 1C05-NU-04225-01)

STATIC AND DYNAMIC TENSIONS IN HUMAN SKIN, J. Peeler<sup>1</sup>, J. Thacker<sup>2</sup>, F. Allaire<sup>3</sup>, Mechanical Engineering Dept., Univ. of Va., Charlottesville, Va. 22901

During each operative procedure a surgeon must design excisions or incisions to promote healing and minimize scar tissue. A double cantilevered quasi-static extensometer has been developed and used to inform the surgeon of directional skin properties before operations. These properties are affected by both static and dynamic tensions due to the skin being stretched over the muculoskeletal system. The extensometer is used to produce *in vivo* force - deflection curves in several directions. A two parameter theoretical model has been developed to characterize the skin. Experiments have been carried out to verify the theoretical model.

THE EFFECTS OF PERITONEAL EXUDATE CELLS AND SERUM FROM PYRAN TREATED MICE ON SURVIVAL TIME OF MICE HOSTING THE LEWIS LUNG CARCINOMA, L.C. Mattee<sup>1</sup>, S.H. Smith<sup>2</sup>, and A.E. Munson<sup>3</sup>, W. Dewey (Sponsor) Dept. of Pharmacology and MCW/VCU Cancer Center, Med. Col. of Va., Richmond, Va. 23298

It has previously been shown that passive transfer of peritoneal exudate cells (PEC) and serum from pyran-treated mice inhibits Friend leukemia disease. In this study PEC and serum from BDF<sub>1</sub> mice were tested for their ability to prolong the lifespan of mice hosting the Lewis Lung (LL) carcinoma. LL cells were injected into the footpad and after metastases had occurred, the primary tumor was surgically removed. PEC and serum, collected from mice treated i.p. daily with pyran (25 mg/kg) for 5 days, was administered 3 times a week for 2 weeks. PEC and serum were administered by the i.v. and/or i.p. route. Mean survival time (MST) for the control group was 28.9±2.4 (S.E.) days with one 64 day survivor. The positive control groups cyclophosphamide and pyran gave MST of 57.3±4.2 with 3 long term survivors, and 37.8±2.7, respectively. Mice treated with PE cells i.p. had an MST of 29.3±3.6 with 3 long term survivors. The i.v. and combined i.v., i.p. PEC-treated mice survived 33.7±1.7 and 32.9±3.4, respectively. Mice treated with serum by the i.p. and i.v. route had MST of 32±2 and 33±2 days, respectively. These studies indicate that pyran treated PEC and serum do not possess the same degree of antineoplastic activity in the LL as seen in Friend leukemia disease. Supported in part by USPH grants CA17551, DA1312 and IT326M97111.

THE EFFECTS OF NICOTINE WITHDRAWAL ON THE SLEEP AWAKE CYCLE, L.C. Parsons and Steve Hamee<sup>1</sup>, Sch. of Nursing and Dept. of Physiology, Sch. of Medicine, Univ. of Va., Charlottesville, Va. 22903

Ten healthy females between the ages of 21 and 25 yrs. and having smoked for at least 2 yrs. were divided into two groups of 5 persons each. All subjects were electrophysiologically monitored for 4 or 6 consecutive nights depending upon the length of nicotine abstinence. The first night of each study served as a conditioning night. Group 1 abstained from smoking for a period of 24 hrs. while Group 2 abstained from smoking for a period of 48 hrs. All subjects who smoked in excess of 20 cigarettes per day showed decreases in heart rate (HR) between 4 and 8 beats per minute on withdrawal day 1, W<sub>1</sub>, and/or withdrawal day 2, W<sub>2</sub>, in all stages of the sleep awake cycle. Respiratory rates (RR) in the majority of cases and under similar conditions, showed decreases on both W<sub>1</sub> and W<sub>2</sub>. Both HR and RR showed increases on recovery day 1 (R<sub>1</sub>) and recovery day 2 (R<sub>2</sub>) with HR's tending to overshoot control levels on R<sub>1</sub>. In subjects smoking more than 20 cigarettes per day, delta sleep tended to increase by 25 to 50% on W<sub>1</sub> and W<sub>2</sub> nights and returned to normal values on R<sub>1</sub> and R<sub>2</sub>. The latency to light and delta sleep onset were appreciably decreased on W<sub>1</sub> and W<sub>2</sub> and tended to return to control latencies on R<sub>1</sub> and R<sub>2</sub>. (Aided by NIH Grants RO-2-NU-00345-06 and 1C05-NU-04225-01)

POLYMORPHIC RESPONSES TO EXPERIMENTAL STRESSES OF MURINE MELANOCYTES, W. M. Reams, Jr., Dept. Biology, Univ. of Richmond, Richmond, Va. 23173

In the epidermis of PET/Amr mice, a small number of weakly DOPA-reactive, miniature melanocytes are seen to occur dispersed among the typical melanocytes. In attempts to determine the nature of the miniature melanocytes, the dorsal skin of mouse puppies and adults was subjected to treatment with ultraviolet light or nitrogen mustard. These stresses provoked increases in the population of typical melanocytes and induced a marked hypertrophy and increased dendritic formation in many of the cells. However, the population of miniature melanocytes appeared to be unresponsive to the stresses.



WARNING SYSTEM FOR WHEEL-CHAIR BOUND PARAPLEGIC PATIENTS TO PREVENT DECUBITUS ULCERS. A. E. Sanderson\*, P. E. Allaire\*, and F. Wickers\*, Mechanical Engineering Dept., Univ. of Va., Charlottesville, Va. 22901.

Patients who have recently become wheel-chair bound paraplegics have difficulty in learning to move regularly to prevent decubitus ulcers. They often cannot adjust to the loss of pain sensation in their lower body. An electronic warning device for attachment to the wheel-chair has been designed and constructed. A variable time period of approximately fifteen minutes has been found by other researchers as appropriate for patients to push themselves upwards and allow sufficient circulation to occur. After this length of time a buzzer starts indicating that the patient should move. Upon return, the timing period starts again. It has been estimated that this device may save \$25,000 in potential medical costs for curing one patient susceptible to decubiti.

ROLE OF THE ADRENAL GLAND ON IMMUNOSUPPRESSIVE ACTIVITY OF  $\Delta^9$ -TETRAHYDROCANNABINOL ( $\Delta^9$ -THC), S.H. Smith\*, J.A. Levy\* and A.E. Munson\* W. Dewey (Sponsor) Dept. of Pharmacology and the MCV/VCU Cancer Ctr. Med. Col. of Va. Richmond, Va. 23298

Delta 9-THC has been shown previously to suppress antibody and cell mediated immunity.  $\Delta^9$ -THC given 2 days after immunization with sheep erythrocytes (sRBC) reduced spleen antibody forming cells as measured by hemolytic plaque forming cells (PFC)/ $10^6$  spleen cells or PFC/spleen. The ED<sub>50</sub> for  $\Delta^9$ -THC on peak day of response was 70 mg/kg. These experiments investigated the role of the adrenal gland in the suppressive action of  $\Delta^9$ -THC. Adrenalectomized BALB/c mice maintained on 20  $\mu$ g/mouse/day of corticosterone were injected with  $4 \times 10^7$  sRBC on day 0.  $\Delta^9$ -THC was given i.p. on day 2 at doses of 50 or 75 mg/kg. PFC/ $10^6$  spleen cells were enumerated on day 4. In the vehicle control group 460 PFC/ $10^6$  spleen cells were reduced to 65% and 52% of control by 50 and 75 mg/kg  $\Delta^9$ -THC respectively. Likewise PFC/spleen were reduced in a dose-dependent manner to 72% and 53% of control. These values did not differ significantly from those derived from sham-operated mice. We therefore, concluded that  $\Delta^9$ -THC does not suppress the production of antibody forming cells by causing a release of adrenal corticosteroids. Supported in part by USPH grants, DA1312, CA17551 and IT326H07111.

PASSIVE TRANSFER OF ANTI-FRIEND LEUKEMIA ACTIVITY WITH PERITONEAL EXUDATE CELLS (PEC) AND SERUM FROM PYRAN (PCP) AND POLYMALEIC ANHYDRIDE (PMA) TREATED MICE, E. Twardzik\*, G. Schullert\* and A. Munson\*, W. Dewey (Sponsor) Dept. of Pharmacology and the MCV/VCU Cancer Ctr. Med. Col. of Va. Richmond, Va. 23298  
Balb/c mice were treated i.p. with PMA-D 25 mg/kg (30,000  $\times$   $10^6$  cells) and ED<sub>50</sub> 1.63 mg/kg for 5 days before harvesting bone marrow cells, peritoneal exudate cells (PEC), spleen cells, and serum. Donor cells and serum were injected i.p. into mice which were challenged with Friend leukemia virus (FLV) 24 hrs. later. Serum, spleen cells, and bone marrow cells transferred no protection against FLV disease as determined by splenomegaly. PEC produced a 40% inhibition of splenomegaly. PCP (ED<sub>50</sub> 0.75 mg/kg), PCP-C (50,000  $\times$   $10^6$  cells) and PMA-C (50,000  $\times$   $10^6$  cells, ED<sub>50</sub> 2.50 mg/kg) were administered according to the above procedure. Serum, PEC and PEC supernatants were injected into mice which were challenged with FLV 24 hrs. later. PCP-C, PMA-C, and PCP serum inhibited splenomegaly 61%, 62%, and 67% respectively. PCP-C, PMA-C and PCP 2x10<sup>7</sup> PEC inhibited splenomegaly 77%, 74% and 72% respectively. PCP-C, PMA-C, and PCP 1x10<sup>7</sup> PEC inhibited splenomegaly 61%, 52% and 49% respectively. PCP-C and PMA-C supernatants inhibited splenomegaly 84% and 70% respectively. Serum, PEC and PEC supernatant from glycogen treated mice transferred no protection to recipient mice. Passive transfer of PEC and serum from PCP-C, PMA-C and PCP treated mice protect against FLV disease. Supported in part by grants USPH CA 17551, DA1312-01, IT326H97111 and Amer. Can. Soc. (N105).

AN APPARATUS FOR THE CONFORMATIONAL STUDY OF PROTEINS AND NUCLEIC ACIDS BY TRANSIENT ELECTRIC BIREFRINGENCE. R.C. Williams, M.R. Thompson, and C.H. O'Neal  
Dept. of Biophysics, MCV-VCU, Richmond, Va. 23298

The birefringence apparatus described has a resolution time of 8 nsec. With this apparatus, two relaxation times have been detected for a number of interesting proteins. These two relaxation times uniquely determine the dimensions of the equivalent ellipsoids of revolution for these proteins in solution. Therefore, the method of transient birefringence coupled with apparatus having a resolution time of at least 8 nsec. is a valuable tool in the study of hydrodynamic properties of proteins.

Relaxation times of 15-25 nsec. in double exponential decay were observed with aqueous solutions of TRNA and several purified proteins. These molecules were modeled as ellipsoids and their dimensions and axial ratios calculated by the method of Wright were found to agree with measurements obtained by other procedures.

The magnitude and sign of the birefringence signal and the relaxation time for TRNA was found to vary considerably with temperature, indicating that this method will be very useful for studies of conformational changes not observed by usual Tm methodology. Dimensions of ellipsoidal axes for TRNA and bovine serum albumin were found to be 35  $\times$  110A and 141  $\times$  42 A respectively. Molecular weight of protein can also be determined. (Supported in part by NSF Grant GB-14046).

DETECTION AND CHARACTERIZATION OF HOST CELLS WITHIN SOLID TUMORS. S.C. Johnson\*, A.M. Kaplan\*, J.A. Munson\*, S. Bilgin\* and P.S. Morahan. Medical College of Virginia, Richmond, Virginia 23298.

The present study was initiated to identify the tumor associated host cells (TAHC) within several different murine tumors; Lewis lung carcinoma (LL), two methylcholanthrene tumors (MCA-2182 and MCA-2115) and the B-16 melanoma (B16). TAH macrophages were identified by esterase activity, phagocytosis of latex particles and adherence to and spreading on glass. Fc receptor bearing TAHC were determined by rosetting with antibody coated erythrocytes. The number of macrophages in the LL as detected by adherence and spreading remained at 7-11% of the total tumor cells between days 14 and 28 after tumor cell inoculation. In general there was agreement between the number of esterase positive and phagocytosis positive cells, although these values were frequently lower than the values determined by adherence. The percent of macrophages as determined by adherence and spreading 21 days after tumor cell inoculation varied from 10% to 12% for the four tumors. In the LL the number of Fc receptor positive cells was comparable to the number of macrophages suggesting that in this tumor there were few non-macrophage Fc receptor positive B-cells or null cells.

## Section of Microbiology

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1974, Fairfax, Virginia

CYTOCHEMICAL LOCALIZATION OF REDUCED TETRAZOLIUM  
TETRAZOLIUM (TNBT) IN DIFFERENTIATED *Glucobacter oxydans*  
DURING OXIDATION OF SORBITOL. L. Scott Andrews\* and G. W.  
Claus. Va. Polytechnic Inst. and State Univ., Blacksburg,  
Va. 24061

*Glucobacter oxydans* subsp. *suboxydans* is characterized by rapid single-step oxidations carried out by membrane-bound dehydrogenases. Earlier work demonstrated that maximum stationary phase (MSP) cells contained quantities of intracytoplasmic membranes (ICM) and that they oxidized polyols twice as fast as exponentially growing (Exp) cells that lacked this membrane development. This research was initiated to determine (a) if polyol oxidation stimulates TNBT reduction, (b) if reduced TNBT is deposited with ICM complexes such that the ICM can be detected with the light microscope, and (c) if the reduced TNBT could be quantitatively extracted from cells. Exp cells devoid of ICM were harvested from a chemically complex medium at 0.1 OD<sub>620</sub>, and MSP cells containing ICM were harvested shortly after reaching MSP (1.5 OD<sub>620</sub>). TNBT was reduced by cells incubated with sorbitol, and light microscopy revealed deposition in the polar regions of MSP cells. No significant deposition occurred within Exp cells. When these cells were treated with alkaline dimethylformamide (DMF) at pH 12.6, both cells and reduced TNBT were solubilized. We are currently using DMF extraction to quantitatively determine the extent of sorbitol dehydrogenase activity in cells containing and those lacking ICM.

ISOLATION AND IDENTIFICATION OF *Glucobacter* FROM NATURAL MATERIALS. G. W. Claus and C. A. Baker\*. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Recently we have found a need for a simple, effective method for selecting *Glucobacter* from habitat material. Although there are many media described for use in selection of these bacteria, there are no previous reports that test their reliability and accuracy using nationally recognized species. Using species of *Glucobacter* and *Acetobacter* obtained from ATCC, we tested a combination of five different media for the ability to detect biochemical differences between these closely related bacteria. The cultures were first tested for the ability to grow on a media containing 10% Glucose at a pH 4.5. Then each was tested for acid production from both glucose and ethanol, dihydroxyacetone production from glycerol, and growth on calcium lactate. The results show that these media can clearly distinguish *Glucobacter* from *Acetobacter*. Based on this information, we have used these media to select for and identify *Glucobacter* in ten different samples of habitat material. The material was first blended, and streaked on media containing 10% Glucose at pH 4.5 to select for acetic acid bacteria. From these plates 234 colonies were tested on each of the differential media. Twenty-six separate strains of *Glucobacter* have been isolated from these colonies. The time required to isolate and identify *Glucobacter* from the habitat material is approximately seven days.

PHYSIOLOGICAL PARAMETERS OF COXSACKIEVIRUS-INFECTED OUTBRED MICE. Rashid Bhavnagri\*, S. R. Webb\* and R. M. Loria\*. Dept. of Microbiol., Va. Commonwealth Univ., Richmond, Va. 23298

It has been reported by others that a prototype strain of Coxsackievirus B4 (CB4) induces diabetes in mice of the outbred strain, CD-1. The disease was characterized by transient hyperglycemia, glucose intolerance and beta cell degeneration. The reproducibility of these observations has recently been questioned. The present study was initiated in order to verify the role of acute CB4 infection in the outbred mouse and extend it to 21 weeks after infection.

6-8 week old males of the CD-1 strain were given single intraperitoneal inoculations with the Edward's isolate of CB4. Control animals were inoculated with virus-free diluent. CB4 replicated to a high titer in the pancreas, approximately 10<sup>5</sup> PFU/gm in Hela cells.

Weight, fasting glucose, nonfasting glucose and glucose tolerance tests were normal at 1,2,3,4,6,10,12,16 and 21 weeks after infection. In addition glycosuria, ketonuria, polyuria, and excessive albuminuria were never detected. pH of the urine remained normal. Insulin insufficiency was never apparent.

These studies indicate that CB4 (Edward's isolate) does not produce either transient or persistent diabetes-like disease in the CD-1 mouse. However, this virus can produce a diabetes-like disease in mice which are heterozygous for the diabetes gene, db. We conclude that some degree of genetic susceptibility is a prerequisite for the development of diabetes-like disease following CB4 infection.

MICROSPECTROPHOTOMETRIC DETERMINATIONS OF NUCLEAR DNA CONTENT IN BINUCLEATE NEURONS. C. D. Cone, Jr. and Max Tongier Jr. Cell and Molec. Bio. Lab., VA. Ctr., Hampton, VA 23667

DNA synthesis and mitosis have been induced in vitro in fully differentiated neurons of the central nervous system by depolarization with ouabain. Since cytokinesis was not usually completed, the mitoses resulted in formation of binucleate neurons. Relative amounts of DNA in nuclei of control (G<sub>1</sub>) neurons and in daughter nuclei resulting from mitoses were determined by Feulgen microspectrophotometry of individual nuclei. The nuclear DNA content of G<sub>1</sub> fibroblasts in the cultures was similarly determined by using an excess-thymidine blocking procedure for accumulating G<sub>1</sub> cells to establish the basic diploid DNA level. Neuron cultures were Feulgen-stained by the procedure of DeCosse and Aiello, and the relative absorbancy of each nucleus was determined at 550-nm wave length by using a Zeiss fluorescence microscope integrated with a model 240 Gilford monochromator and digital photometer. Measurements of the DNA content of each of the daughter nuclei in 62 binucleate neurons resulting from ouabain-induced divisions revealed that each of the 124 daughters contained identical amounts of DNA. The DNA content of each daughter nucleus from induced divisions was found to be identical also to that of the mononucleate neurons in controlled cultures. Since each of the 101 controlled neurons assayed contained the same amount of nuclear DNA as the G<sub>1</sub> (diploid) fibroblasts in cultures, control and test neurons were diploid cells prior to treatment.

THE ROLE OF MACROPHAGES AND MACROPHAGE-DERIVED FACTORS IN MIXED LYMPHOCYTE REACTIONS. K. M. Connelly\* and K. D. Elgert. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The mixed lymphocyte reaction assay was used with purified monoderm mouse spleen cells (T cells) to determine if the T cell-mediated response to allogeneic cells is dependent on the presence of macrophages (M) and/or macrophage-derived factors (MF). T cells were characterized by their ability to pass through nylon wool columns.

M were obtained from mice by peritoneal lavage 3 days after intraperitoneal injection of 1 ml of thioglycolate broth. Soluble MF were obtained by 4 day culturing of M in RPMI-1640 medium and subsequent removal of supernatant (S). Varying concentrations of M or S were added to cultures containing mitomycin-C (MC) treated C3H/He mouse spleen cells plus splenic T cells from normal and tumor-bearing Balb/c mice. All assays were performed in U-bottom micro-titer plates and harvested using a Multiple Automated Sample Harvester.

The present study demonstrated that in the absence of M, normal T cells showed a 2 fold decrease in response to allogeneic cells. However, T cell cultures containing a 4% population of MC treated M showed significant stimulation as measured by <sup>3</sup>H-thymidine uptake. In contrast, the T cells from tumor-bearing mice showed a decreased dependence on M.

INNA SYNTHESIS IN VITRO TO MITOGENS AND DURING CONTACT SENSITIVITY IN TUMOR-BEARING MICE. W. L. Farrar\* and K. D. Elgert. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The effects of transplantable tumors on cell-mediated immune competence was studied by utilizing *in vitro* mitogen or hapten-protein conjugate stimulation of lymphocyte (L) inna synthesis. Fibrosarcomas were induced in Balb/c mice by transplanting 2 X 10<sup>5</sup> viable tumor cells from a passaged primary methylcholanthrene-induced tumor. Spleen cells (SC) from Balb/c mice were assayed for contact sensitivity to 1,5-Difluoro-2,4-dinitrobenzene (DNFB) and mitogen responsiveness to Phytohemagglutinin (PHA) and Concanavalin A (Con A) at set intervals during tumorigenesis. Responsiveness was measured by the incorporation of <sup>3</sup>H-thymidine during final 18 hrs of a 72 hr incubation. Lymphocytes were cultured in flat-bottom microtiter plates and harvested using a Multiple Automated Sample Harvester.

Tumor-bearing mice were compared to normal mice in their ability to be sensitized to DNFB and also the specificity of their response to DNFB. In addition, serum from the 2 groups of mice were tested to determine effect on control culture responses. Kinetic studies of SC from tumor-bearing mice showed a 4 fold decrease in response to PHA and Con A. The suppression corresponds to tumor size and duration of tumorigenesis. Depression of contact sensitivity, a T cell associated function, showed similar results. (Aided by Elsa U. Pardee Foundation Grant)

DEMONSTRATION OF UNIQUE MECHANICAL COMPONENTS IN STRAINS OF CANDIDA ALBICANS. K. E. Hannan, T. C. Burgess\* and B. A. Jocks. Dept. of Biological Sciences, Old Dominion University, Norfolk, 23508.

Cytoplasmic extracts from blastospore and mycelial phases of avirulent and virulent strains of *Candida albicans* were compared by sodium dodecyl sulfate (SDS) polyacrylamide gel electrophoresis. Cytoplasmic extracts were made by disrupting cultures of *Candida albicans* in a Braun homogenizer followed by ultracentrifugation. The supernatant fractions were separated on polyacrylamide gels containing SDS. Each of the preparations yielded a distinct pattern. The number of protein bands observed was directly related to strain virulence. A greater number of protein bands was shown for virulent strains than for intermediately virulent or avirulent strains. Moreover, the number of bands resolved for blastospore extracts was greater than for mycelial forms in all strains tested. Relative pathogenicity of strains of *Candida albicans* was determined by their ability to produce oral disturbances, decreased growth rates, and mortalities in 2-week old chickens. These results demonstrate that virulence and increased numbers of electrophoretic protein bands are positively correlated.

CAN FTA-ABS BORDERLINE TEST RESULTS BE RESOLVED IN THE LABORATORY DIAGNOSIS OF SYPHILIS? M. R. Escobar and H. P. Dalton. Med. Col. of Va., Richmond, Va. 23298

The fluorescent treponemal antibody-absorbed (FTA-ABS) procedure, or its automated modification (AFTA), is still the most sensitive yet highly specific test available for the laboratory diagnosis of syphilis. Nevertheless, a borderline (B) reactivity occurs with a frequency of about 25, even when repeat samples are tested. This finding hampers the interpretation of laboratory results and places the diagnostic responsibility entirely on the clinician. We attempted to resolve this problem by the use of several methods for macromolecule concentration, thereby increasing the immunoglobulin content of the patient's serum. Of these, two were selected for the present study because of their simplicity, efficiency, speed and reproducibility. They were the ultrafiltration procedure using the disposable A25 Minicon concentrator and a gel absorption technique with polyacrylamide gel (Lymphogel). Nonreactive (NR), reactive (R-VDR, R-AFTA; NR-VDR, R-AFTA) and biological false positive (BFP-R-VDR, NR-AFTA) sera were included as controls. Tests were performed in duplicate before and after 3-4 times concentration of each serum at 4C overnight. At least 60% of the B sera became R after concentration with the Minicon concentrator. In one case a BFP serum became R. However, all the NR and R sera remained unchanged following concentration. The Minicon procedure appeared to be more efficient and reproducible than the Lymphogel technique. Further evaluation of this approach is underway in terms of specificity and reliability.

CORRELATION OF VIRULENCE IN *LISTERIA MONOCYTOGENES* WITH THREE *IN VITRO* REACTIONS. R.D. Grove\* and H.J. Welshimer, Med. Col. of Va., Richmond, Va. 23298

Although virulent (V) strains of *Listeria monocytogenes* may be recognized by *in vivo* methods, *in vitro* reactions correlated with virulence would be advantageous. The reactions of *L. monocytogenes* on xylose and rhamnose and the potentiation of hemolysis of *L. monocytogenes* by a CAMP phenomenon (CP) were determined with 112 strains isolated from diverse sources, clinical and non-clinical. Using 15 xylose or rhamnose in purple broth base, a positive (+) reaction was defined as acidification of the carbohydrate within 72 hr while a negative (-) reaction was defined as no acidification within 14 days. All 26 xylose + strains were avirulent (AV) while 76 of 86 (89.42%) xylose - strains were V. Of 89 rhamnose + strains, 75 (84.32%) were V while 21 of 23 (91.22%) rhamnose - strains were AV. The CP was determined by a procedure similar to the CAMP reaction used in identifying group B streptococci. The *Listeria* strains were streaked on sheep blood agar perpendicularly to a streak of beta-toxin producing *Staphylococcus aureus*. After incubation, a + CP was detected with the appearance of a rectangular zone of complete hemolysis surrounding the *Listeria* streak within the diffusion zone of the staphylococcal toxin. Of the 77 CP + strains 76 (98.7%) were V while all 35 CP - strains were AV. These tests will be useful in the *in vitro* separation of virulent from avirulent *L. monocytogenes* strains isolated from non-clinical sources.

PERTURBATION OF THE COMPOSITIONAL INTEGRITY OF WI-38 CELLS IN CULTURE BY BACTERIAL LIPOPOLYSACCHARIDE. C. Hanscom\* and S.G. Bradley, Dept. of Microbiology, Virginia Commonwealth University, Richmond, Va. 23298

The effects of bacterial lipopolysaccharide (LPS) on WI-38 cells, a human embryonic lung continuous cell line in its 22nd to 25th passage, have been investigated. The WI-38 cells were cultivated in Modified Eagle's Medium with Earle's balanced salt solution, glutamine and 5% (v/v) fetal calf serum. *Escherichia coli* O26:B6 lipopolysaccharide (Westphal preparation) at a concentration of 100 µg/ml did not significantly alter the extent of incorporation of radiolabeled adenine (Ade), uridine (Urid), leucine (Leu) or serine (Ser) during a 4 hr period or thymidine labeling in 36 hr period. Similarly, the anti-tumor alkaloid vincristine (VNC) at a concentration of 0.01 µg/ml had scant effect on the incorporation of radiolabeled Ade, Urid, Leu or Ser. The combination of 100 µg LPS/ml and 0.01 µg VNC/ml significantly reduced the incorporation of Ade, Urid, Leu or Ser. The combination of 10 µg LPS/ml and 0.01 µg VNC/ml detectably reduced the incorporation of these radiolabeled metabolites. The combination of LPS and VNC was able to retard the incorporation of radiolabeled metabolites in the presence or absence of fetal calf serum. Bacterial LPS apparently rendered the WI-38 cells more susceptible to the cytotoxic action of VNC. LPS did not dramatically increase the cytotoxicity of the antibacterial antibiotics chloramphenicol, streptomycin or tetracycline for WI-38 cells.

**ACID-INDUCED PLASMOLYSIS AND ITS EFFECT ON VIABILITY OF *Glucobacter caydoni*.** D. L. Heffner\* and G. W. Claus. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061  
*Glucobacter caydoni* (*Acetobacter caydoni*, ATCC 621) oxidizes large quantities of glucose to gluconic acid during growth. We recently observed that the subsequent drop in culture pH was accompanied by plasmolysis and other changes in cell structure. The observed plasmolysis was surprising, because previous attempts to plasmolyse these cells with concentrations of up to 70% sucrose were unsuccessful. To determine the effect of pH on plasmolysis, cells were washed in  $\text{dH}_2\text{O}$ , suspended in buffered saline, then incubated with shaking at 28C. Uniform plasmolysis and a complete loss of viability occurred after 60 min at pH 3.0, after 120 min at pH 3.2, and after 180 min at pH 3.4. The addition of 1.5 M sucrose or 20% Ficoll to the pH 3.2 buffered saline drastically inhibited plasmolysis and cell death. Washing cells in 0.9%  $\text{MgCl}_2$  instead of  $\text{dH}_2\text{O}$  prior to incubation at pH 3.2 also inhibited plasmolysis and death, but washing in 0.9% NaCl did not show this protection. These results suggest that plasmolysis is directly related to cell viability. Preliminary studies show that acid-induced plasmolysis is a property that is not limited to the genus *Glucobacter*.

**THE EFFECTS OF ANAEROBIC NITRATE RESPIRATION ON THE MULTIPLE PATHWAYS OF GLUCOSE UTILIZATION IN *PSEUDOMONAS AERUGINOSA*.** J. C. Hunt and P. V. Phibbs, Jr., Virginia Commonwealth Univ., Richmond, Va. 23298  
*Pseudomonas aeruginosa* PAO was impaired in its ability to utilize glucose via initial oxidation to gluconate (the direct oxidative pathway) when cells were grown under conditions of anaerobic  $\text{NO}_3^-$  respiration. The rate of anaerobic gluconate uptake, in the presence of  $\text{NO}_3^-$ , was 3 to 4-fold lower in anaerobic glucose-grown cells than in anaerobic gluconate-grown cells. In contrast, high rates of aerobic gluconate uptake were demonstrated in cells cultured aerobically on either glucose or gluconate. Inducible, membrane-bound glucose dehydrogenase (GDH) activity was very low in membrane preparations from anaerobically grown cells, but was high in membranes from aerobically grown cells. Gluconokinase was induced to high specific activities in cells cultured aerobically or anaerobically on gluconate and in aerobic glucose-grown cells. In contrast, anaerobic glucose-grown cells formed minimal, non-induced levels of gluconokinase activity. The rate of incorporation of  $^{14}\text{C}$ -glucose into acid-insoluble material by aerobic glucose-grown cells was reduced 2-fold in the presence of equivalent unlabeled glucose; little or no inhibition by gluconate was observed with anaerobic glucose-grown cells. The oxidative pathway for glucose catabolism (via gluconate) is functional in aerobically grown cells but it may not function significantly in cells grown under conditions of anaerobic  $\text{NO}_3^-$  respiration. The direct phosphorylative pathway (via glucose-6-P) appears to be the major route for anaerobic glycolysis.

**IMMUNOLOGIC TOLERANCE TO HUMAN GAMMA GLOBULIN IN MICE: INDUCTION IN NORMAL MICE WITH A CELL SOLUBLE EXTRACT FROM TOLERANT ANIMALS.** Tom B. Jones\* and Alan M. Kaplan\*, Medical College of Virginia, Richmond, Virginia, 23298.  
Spleen cells from A/J mice tolerant to HGG actively induced tolerance to HGG in normal A/J recipients. The inoculation of  $10^4$  to  $10^8$  spleen cells from tolerant donors suppressed the antibody response of normal A/J mice 95% to an immunogenic challenge with heat aggregated HGG (AHGG). Similarly, a 24,000 xg supernatant from  $10^6$  sonicated spleen cells from tolerant mice suppressed the response of normal A/J mice 95% to a challenge with AHGG. Dilution of the supernatant to the equivalent of  $10^4$  cells was equally suppressive. The suppression induced by both spleen cells and cell extract was found to be specific as evidenced by a normal response to a challenge with goat erythrocytes (GRBC). Thymus cells or a sonicated supernatant of thymus cells from tolerant donors induced suppression of the antibody response to HGG. However, some nonspecific suppression of the antibody response to GRBC was associated with both the thymus cells and the thymic factor. Studies are currently underway to characterize further the functional and biochemical nature of this factor. Supported in part by NIH grant #AI 11561.

**EFFECTS OF PRIOR IMMUNIZATION ON ORAL HERPETIC LESIONS AND THEIR SEQUELAE IN A MOUSE MODEL SYSTEM.** E.N. Kitecs\*, J.G. Tew, L.M. Abbey\*, M.J. Payne Jr.\*, J.T. Povlishock\*, and B.K. Murray. Department of Microbiology, Medical College of Virginia, Richmond, Virginia 23219  
The object of this study was to develop a mouse model system for studying the effects of prior immunization on encephalitis and latency following oral infection with herpes simplex virus, type 1 (HSV-1). Three to five days after administration of HSV to abraded oral epithelial surfaces, 90-100% of 5-10 week old male BALB/c mice developed 1-3 mm confluent oral vesiculo-ulcerative lesions from which HSV was isolated. Histological and electron microscopic evidence of herpetic infection was demonstrated. Oral lesions resolved within two weeks, however, 15-30% of the mice died of herpetic encephalitis between the 7th and 15th day. After clinical recovery from oral infection, infectious virus could not be isolated either from the original lesion site or from the regional sensory (trigeminal) ganglia. However, 75-100% of the mice were latently infected as demonstrated by recovery of infectious virus from explanted ipsilateral, but not contralateral ganglia. Mice immunized prior to oral infection with formalin-inactivated HSV or glutaraldehyde-polymerized HSV developed less severe initial oral lesions. In addition, these immunized mice were uniformly protected from both encephalitis and latent infection. This model system is well suited for the study of pathogenesis and neurological sequelae of oral herpetic infections.

**DIFFERENTIATION OF HERPES HUMANIS, TYPES 1 AND 2, IN 3-WEEK OLD MICE.** M. P. McCann\* and M. R. Escobar. Med. Coll. of Va., Va. Commonwealth University, Richmond, Va. 23298  
The known biological differences, including oncogenicity, between types 1 and 2 of *Herpes hominis* as well as epidemiologic and immunotherapeutic considerations led us to evaluate several typing methods on the basis of simplicity, specificity and reproducibility. Typing of several human isolates by plaque formation in chick embryo fibroblasts (CEF) and/or by peak size in the chorionicallantoic membrane of embryonated eggs (CAM) was compared with that obtained by direct immunofluorescence (DFA) using commercial guinea pig conjugated absorbed antisera. Results obtained by these procedures were confirmed in a reference laboratory by DFA using non-commercial rabbit conjugated absorbed antisera. An attempt was made to reproduce a simpler method reported independently by two groups of investigators which was based on the formation by type 2 of grossly visible necrotic foci in the liver of 3-wk old mice (MLF). There was good correlation between the anatomic source of the isolate, CEF and/or CAM and the DFA results from the reference laboratory. We were unable, however, to reproduce the MLF procedure since foci were detected only in one case with a type 2 isolate. Only 4 of 7 isolates typed by the DFA method using commercial antisera agreed with results from the other procedures. Certain variables such as the age and strain of mice, passage history of the virus and age of the culture as well as infective dose of virus are being investigated to further evaluate these techniques.

**AN ENHANCED HOST RESISTANCE IN MURINE SALMONELLOSIS INDUCED BY TUBERCULIN SENSITIVITY.** K. B. Miller and H. S. Hsu. Dept. of Microbiology, Med. Coll. of Va., Richmond, Va. 23298  
Previous study in experimental salmonellosis suggested that delayed hypersensitivity to salmonella antigens might aid the acquired resistance of the host to subsequent infections. The present objective is to test whether delayed hypersensitivity elicited by purified protein derivatives (PPD) in tuberculin-sensitive mice can enhance host resistance to challenges with *Salmonella typhimurium*. Swiss Webster mice were vaccinated i.p. with *Mycobacterium bovis* BCG and, 4 to 10 weeks later, challenged i.p. with  $10^5$  S. typhimurium with or without PPD. Normal mice were also challenged with or without PPD. Survival time of the infected animals was recorded for 3 weeks. Results showed that:  $10^5$  salmonellae with PPD caused a fatal infection in normal mice within 12 days; BCG-vaccination prolonged the survival time and protected about 30% of the mice from death; and tuberculin sensitivity elicited by PPD significantly prolonged the survival time and protected about 70% of the mice from death. When the challenge dose was increased to  $10^6$  salmonellae, the protective effect of tuberculin sensitivity was no longer apparent. The accelerated influx of monocytes and polymorphs induced by delayed hypersensitivity is believed to be an essential factor of enhanced resistance to infection as observed in this study.

ALTERED LEUKOCYTE CHEMOTAXIS AND PHAGOCYTOSIS DURING AFLATOXICOSIS. R. P. Olson, P. B. Hamilton\*, B. A. Weeks, Dept. of Biological Sciences, Old Dominion University, Norfolk, 23508 and Dept. of Microbiology, North Carolina State University, Raleigh.

Aflatoxicosis can result in enhanced susceptibility of chickens to infectious diseases despite normal levels of circulating antibodies. This suggests impairment of some aspect of cell-mediated immunity. The chemotactic ability of leukocytes from chickens given graded levels of aflatoxin was measured using the modified Boyden technique, with guinea pig complement (CSA) as the chemotactic stimulus. Chemotaxis was inhibited ( $P < 0.05$ ) at growth inhibitory levels of aflatoxin (2.5  $\mu\text{g/g}$  or greater). The ability of heterophils to phagocytize *Enterobacter cloacae* was measured as a function of dietary aflatoxin, revealing several populations of heterophils. A crossover experiment using sera and leukocytes from control birds and birds with aflatoxicosis revealed that aflatoxin inhibits both a cellular factor and a humoral factor involved in phagocytosis.

INTRACELLULAR CYCLIC AMP LEVELS IN TUMOR-BEARING MALNOURISHED GUINEA PIGS. D. M. Ostrowsky, W. L. Donley and B. A. Weeks, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Protein calorie malnutrition has been found to depress resistance to infection by the cell-mediated immune mechanism in animal models as well as in humans. Clinical observations have further indicated a higher incidence of cancer among malnourished populations. The mechanism for this process is not completely clear, however, our earlier studies on the plasma levels of cyclic AMP (cAMP) in malnourished and control guinea pigs indicated a significant decrease in levels of cAMP in the experimental group, thus indicating a possible role of cAMP. This led us to investigate the levels of cAMP in the spleen, thymus and plasma of control and malnourished guinea pigs with and without the intradermal injection of line 10 (hepatoma) tumor cells. The results indicate that there was a decrease in cAMP levels in the spleen during malnutrition, and recovery was noted 10 days after the period of malnutrition. Spleen levels in the nontumor groups were twice that of the tumor groups suggesting the possibility of a decrease in cAMP with increased immunological activity due to the presence of tumors.

PATHOGENESIS OF ORAL HERPES SIMPLEX VIRUS INFECTION IN MICE. W. J. Payne, Jr.\*, P. H. Coleman\*, B. K. Murray. Dept. of Microbiology, Virginia Commonwealth Univ., Richmond, Va. 23298

Primary oral infection by herpes simplex virus, type 1, (HSV-1), is thought to be a prerequisite for recurrent herpetic lesions (commonly known as cold sores). In addition HSV-1 is a leading etiologic agent of sporadic aseptic encephalitis in humans. Our laboratory studied the pathogenesis of HSV-1 lip infections in ICR mice.

The presence of HSV-1 was monitored daily by isolation of infectious virus and by fluorescent antibody microscopy. Virus was demonstrated in the lip lesions from day 1 through day 8 after inoculation. Sequential infection of the regional sensory ganglia (trigeminal) was evident by day 2. The infection progressed to the cerebellum by day 4 and to the cerebrum by day 6. The contralateral trigeminal ganglia was infected by day 5. Virus could rarely be isolated from the spinal cord and never from the heart, liver, spleen, kidney or blood. Herpetic encephalitis was observed in some mice during acute infection. Susceptibility to herpetic encephalitis was both age and dose dependent, with 25% mortality in 5 wk old mice and 0% mortality in 9 wk old mice. Up to 3 months after remission of clinical lesions, latent HSV-1 could be recovered from 80% of explanted trigeminal ganglia.

PLASMID DNA ISOLATION IN STREPTOCOCCUS MUTANS: GLYCINE-ENHANCED CELL LYSIS. J. L. Reider\* and F. L. Macrina\*. Dept. of Microbiol., Virginia Commonwealth Univ., Richmond, Va. 23298

A new method for the lysis of *S. mutans* based on cell sensitivity to glycine is presented. Log phase cultures incubated 2-5% glycine exhibit negligible cell division after 20h, though DNA synthesis continues as monitored by incorporation of  $^3\text{H}$  thymidine into acid insoluble material. Washed cells are sequentially treated with lysozyme and pronase, and rendered sensitive to ionic detergent lysis with either sodium lauryl sulfate or Sarkosyl NL-97. Lysis is immediate and is always greater than 80% as measured by  $^3\text{H}$  DNA released from cells. Glycine-grown cultures, untreated with lysozyme and pronase are refractive to lysis, and it appears there is a synergistic effect between glycine treatment and the enzymatic digestion of the cell wall. The effect of altering times of glycine and lysozyme incubations was determined and maximal lysis could be achieved after incubations of 40' and 60', respectively. The method provided gentle lysis in over twenty strains tested, and could be used for isolation of a known plasmid in *S. mutans* LM-7.

SURVIVAL OF POLIOVIRUS, TYPE 2, W-2 IN NATURAL WATER SOURCES OBTAINED FROM SOUTHEASTERN VIRGINIA. M. J. Roberts, P. C. Haggerty\* and J. C. Johnson\*. Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

The survival of poliovirus, type 2, strain W-2, in the natural water obtained from the Atlantic Ocean, Chesapeake Bay, Lafayette River, and Lake Smith was compared to that for artificial sea water and deionized water. Viral titers were measured by plaque assay. After 20 days at 17° in the dark, 2% of the initial virus titer remained in artificial sea water, 12-16% remained in each of the natural waters, and 40% in deionized water. Biphasic inactivation kinetics were observed for each of the natural waters. The initial inactivation rates were 6 to 10-fold greater than the secondary rates. Biphasic kinetics were much less apparent for artificial sea water and were not observed for deionized water. Based on the secondary rate of virus inactivation in the natural waters a 1-log reduction in titer required 60 to 70 days. Virus inactivation was correlated to pH and salinity. The data may be interpreted in terms of a viral aggregation-disaggregation phenomenon.

FORMATION OF A NEW NUCLEAR ENVELOPE AFTER TELOPHASE OF MICRONUCLEAR MITOSIS IN EUPLOTES EURYSTOMUS. J. J. Buffalo, Dept. of Biophysics, Med. Col. of Va., Richmond, Va. 23298

*Euploetes eurytomeus* is a hypotrich ciliate protozoan. This unicellular eukaryotic organism shows the nuclear dualism characteristic of ciliates. *Euploetes* has a diploid micronucleus and a highly polyploid macronucleus. During the cell division cycle, the macronucleus divides by a non-mitotic mechanism; and the micronucleus divides by intranuclear (closed) mitosis, i.e., the nuclear envelope does not break down during mitosis. During telophase the daughter nuclei are separated by a large distance (about 50-60  $\mu\text{m}$ ), while still contained within the original, greatly elongated nuclear envelope. Electron microscopic observations of telophase and early interphase revealed an unusual mechanism for completion of separation and compartmentalization of the daughter nuclei -- the daughter nuclei form a new envelope inside the old one. Forks connecting the outer (old) and inner (new) envelopes are readily observed. When a fork is absent, small membranous vesicles are usually seen at the end of the inner envelope. These vesicles may be a precursor of envelope formation. In the outer envelope pore complexes are present, but not as conspicuous as those of the inner envelope. After cell division the early interphase micronucleus is bounded by a single envelope, but for an occasional small stretch where a remnant of the old envelope can be detected.

CHARACTERIZATION, PURIFICATION AND REGULATION OF 7- $\alpha$ -HYDROXY-STERIOD DEHYDROGENASE FROM *BACTEROIDES FRAGILIS*. J. A. Sherrod and P. B. Hylemon\*. Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23298

Two forms of 7- $\alpha$ -hydroxysteroid dehydrogenase (7- $\alpha$ -DH) have been detected in selected strains of *Bacteroides fragilis*. These two forms are different with respect to pyridine nucleotide specificity, thermal stability, divalent metal cation requirement, and elution profiles from Sephadex G-200 columns. The nicotinamide adenine dinucleotide (NAD)-dependent enzyme was purified 18-fold by gel filtration on a Bio-Gel A-1.5M column, and had a molecular weight of approximately 300,000 daltons. Substrate saturation kinetics were examined and the results showed that the NAD-dependent enzyme has a higher affinity for chenodeoxycholate ( $K_m$ , 0.048 mM) than for cholate ( $K_m$ , 0.22 mM) or glycocholate ( $K_m$ , 0.32 mM). High levels of 7- $\alpha$ -DH activity were found to be associated with the membrane fraction of *B. fragilis*.

There was a 4-fold increase in the specific activity of both the NAD- and NADP-dependent enzymes when 0.5 M sodium cholate was included in a defined glucose growth medium over the same medium containing no bile acid. Both forms of the enzyme were found to be widely distributed in different strains of *Bacteroides fragilis*.

EXTRACHROMOSOMAL ELEMENTS OF *BACTEROIDES FRAGILIS*. W. H. Tinnell and F. L. Macrina\*. Dept. of Microbiol., Virginia Commonwealth University, Richmond, Va. 23298

Johnson [Int. J. Syst. Bact. 23, 308, 1973] has identified ten DNA homology groups of the intestinal anaerobe *Bacteroides fragilis* from nucleic acid association studies. Using these groups as a taxonomic framework, we have screened representative strains of *B. fragilis* for the presence of extrachromosomal (plasmid) DNA. <sup>3</sup>H-thymidine labeled cell lysates were subjected to sodium dodecyl sulfate-salt precipitation and supernatants from such preparations were analyzed using cesium chloride-ethidium bromide equilibrium centrifugation. One strain from each group was examined in this fashion. Six of the strains were judged to contain no detectable plasmid DNA by this method. However, four strains were observed to yield satellite bands corresponding to covalently closed circular plasmid DNA. Plasmid DNA from such gradients was subjected to velocity sedimentation through 5 to 20% neutral sucrose gradients and data from such studies were used to calculate molecular weights of the plasmid molecules. *B. fragilis* VPI 2553 and *B. fragilis* VPI 2393 (both subspecies *fragilis*) were found to contain plasmids of  $22 \times 10^6$  and  $3 \times 10^6$  daltons, respectively. *B. fragilis* VPI 5482 and *B. fragilis* VPI 2302 (both subspecies *thetaiotaomicron*) were found to contain plasmids of  $21 \times 10^6$  and  $3.4 \times 10^6$  daltons, respectively. In both cases, the large plasmids were present in only a few copies per chromosomal equivalent while the small plasmids existed in multicopy pools (>10 copies per chromosomal equivalent). Phenotypic properties conferred by any of these plasmids remain unidentified.

CYCLOC AMP PHOSPHODIESTERASE ACTIVITY IN CELLS TRANSFORMED BY MOUSE SARCOMA VIRUS. J. G. Wallace, Jr.\* and R. D. Sonners\*. Dept. of Microbiology, Eastern Va. Med. Sch., Norfolk, Va. 23501

Cyclic AMP phosphodiesterase activity was measured in normal rat kidney (NRK) cells, and NRK cells transformed by wild type mouse sarcoma virus (MSV) or a temperature-sensitive mutant of MSV. Specific enzyme activity was calculated at substrate concentrations of 1  $\mu$ M (low Km enzyme activity) and 100  $\mu$ M (high Km enzyme activity) under conditions where enzyme activity was linear with respect to incubation time and protein concentration. Both high and low Km enzyme activities were markedly reduced in extracts of MSV-transformed NRK cells relative to uninfected NRK cells. Reduced levels of cAMP phosphodiesterase activity were also detected in extracts of NRK cells transformed by temperature-sensitive MSV (NRK (MSV-1b)) when grown at temperatures permissive or restrictive for expression of the transformed phenotype. The results indicate that changes in cAMP phosphodiesterase activity are not associated with previously reported altered endogenous levels of cAMP detected in NRK (MSV-1b) when grown at permissive or restrictive temperature (Nature 257:58-60, 1975).

AMELIORATION OF THE LETHAL ACTION OF BACTERIAL LIPOPOLYSACCHARIDE FOR THE MOUSE. M. Smith\* and S. G. Bradley. Dept. of Microbiology, Virginia Commonwealth University, Richmond, Va. 23298

A survey was conducted to detect substances that would alter the lethal action for the mouse of gram-negative bacterial lipopolysaccharide (LPS). The test materials selected were related to cyclic adenosine monophosphate (c-AMP) or were salts of divalent cations. The majority of the substances tested did not enhance or decrease the toxicity of LPS for ICR mice at the doses used and when administered simultaneously with LPS by the intraperitoneal route; these inactive substances included adenine, adenosine, adenosine monophosphate, cAMP, dibutyltryl CAMP, glucagon, CaCl<sub>2</sub>, CoCl<sub>2</sub>, MgCl<sub>2</sub>, MnCl<sub>2</sub> and ZnCl<sub>2</sub>. Substances that enhanced the lethality of LPS for ICR mice included ethyleneglycol-bis-( $\beta$ -amino-ethyl ether) N,N'-tetraacetic acid and insulin. Substances that decreased the lethality of LPS for ICR mice included caffeine, theophylline, FeSO<sub>4</sub> and ferric ammonium sulfate. FeSO<sub>4</sub> was most effective in reducing the toxicity of LPS when mixed with LPS before injection. The iron-containing proteins catalase, cytochrome C and ferritin and the iron-chelating agent dipyrrolyl did not alter the toxicity of LPS. The C3H/HeJ mouse is relatively resistant to bacterial lipopolysaccharide. Transfer of spleen cells from LPS-sensitive ICR mice to C3H/HeJ mice did not render the chimeras sensitive to LPS nor did transfer of C3H/HeJ spleen cells render ICR mice resistant to LPS.

ULTRASTRUCTURE OF MYXOID CHONDROSARCOMA WITH MYXOVIRUS-LIKE TUBULES POSSIBLY ETIOLOGICALLY RELATED TO THE DISEASE. S. H. Vernick\*, S. Kay\*, J. Morrison\* and D. Cowan\*. Department of Pathology, Eastern Virginia Medical School, Norfolk, Va. 23501 and Medical College of Virginia, Richmond, Va. 23298

Myxoid chondrosarcoma is a rather rare soft tissue tumor sometimes mistakenly diagnosed as a chordoid sarcoma. In the present study ultrastructural analysis confirmed the diagnosis as myxoid chondrosarcoma.

Characteristics of the tumor cells included bizarre pleomorphic nuclei, large numbers of mitochondria and dilated rough ER containing parallel arrays of tubules. These tubules which measured approximately 200  $\text{\AA}$  in diameter presented a helical periodicity characteristic of myxovirus-like bodies. While myxovirus-like bodies have been seen in other tumors including Burkitt's lymphoma, and osteogenic sarcoma, this is the first reported occurrence in myxoid chondrosarcoma. Relationship of the bodies to the etiology of the disease is as yet unconfirmed.

NEUTROPHIL CHEMOTAXIS IN MALNOURISHED GUINEA PIGS. B. A. Weeks and H. D. Whitten. Department of Biological Sciences, Old Dominion University, Norfolk, Va. 23508

Immunological defects in malnourished animals vary but generally include impaired cell-mediated immunity. Our earlier studies revealed that neonatal malnutrition in guinea pigs resulted in a significant decrease in the ability to display contact sensitivity to DNCB. These findings led us to investigate the ability of polymorphonuclear neutrophils (PMNs) from malnourished animals to migrate *in vitro* toward a chemotactic stimulus. Newborn inbred strain-2 guinea pigs were removed from their mothers 5 days after birth and placed on a restricted diet for a 10 day period. Ad libitum feeding was then resumed and continued until day 40. A normally nourished control group was also maintained. PMNs were collected by cardiac puncture at 5 day intervals and assayed for chemotactic activity by the modified Boyden method, using C5a as a stimulus. The findings demonstrate that chemotaxis in the malnourished group was reduced throughout the 40 day experiment. This suggests that defective neutrophil chemotactic function may result from insufficient dietary intake during the first few weeks of life.

OXYGEN AND CARBOHYDRATE UTILIZATION AND PH CHANGE DURING AXENIC GROWTH OF *NAEGLERIA FOWLERI*. R. R. Weil\* and D. T. John. Dept. of Microbiol., Virginia Commonwealth Univ., Richmond, VA 23298

Efforts to obtain information regarding the physiology of pathogenic *Naegleria* have been hampered by bacterized cultivation and by low yield from unagitated cultures. *N. fowleri* (LEE, WM, NF69) was grown at 37°C in 125 Erlenmeyer flasks containing 0.1% liver digest, 0.1% glucose and 2% calf serum in Page's amoeba saline, pH 6.5. The maximum yield of *N. fowleri* was  $4 \times 10^6$  amoebae/ml with a mean generation time of 5.1 h. Population growth deceleration was accompanied by a 1 unit increase in pH. Oxygen tension decreased from 100% to 85% of saturation during log phase and then increased during stationary phase to saturation. Worthington glucostat assay and anthrone carbohydrate assay on culture medium showed little utilization of carbohydrate during growth. Growth tested in the presence of glucose, fructose, mannose, galactose and no sugar using dialyzed serum showed no significant change. Mean cell size ranged from  $850 \mu^3$  during log phase to  $250 \mu^3$  during stationary phase. Oxygen depletion of the medium, pH increase and carbohydrate results indicate aerobic metabolism with anionic compounds (e.g., amino acids) serving as carbon and energy sources.

TUMOR CELL CYTOTOXICITY MEDIATED BY SYNGENIC MACROPHAGES, H.D. Matres, M.A. Attanasio\*, and M.R. Eschobar. Old Dominion University, Eastern Va. Medical School, Norfolk, and Virginia Commonwealth University, Richmond, Va.

An *in vitro* assessment of macrophage mediated specific tumor cell cytotoxicity has shown macrophages to be under the control of those lymphocytes under thymic control (T cells). Thus, murine T cell-sensitization to allogeneic fibrosarcoma is a result of T-T cell synergy that results in the release of Fc receptors that become fixed to macrophage membranes. This synergy is observed in drug manipulated sensitized T cells, and is evidenced by macrophage activity in two assays known to be dependent on Fc receptors—namely, rosette formation and ADCMC. This has been extended to a syngeneic polyoma-virus induced system. When cortisone resistant Balb/c thymocytes were sensitized to Py3T3 cells *in vitro*, 5 day old supernatants could confer on macrophages specific cytotoxicity in a  $^{51}\text{Cr}$  assay and rosette formation with regressor serum-coated tumor cells. Low levels in both assays were observed to Balb/c embryo-fibroblasts. These results indicate the potential augmentability of macrophage specific anti-neoplastic activity to syngeneic as well as allogeneic tumors.

MACROPHAGE ACTIVITY AGAINST HERPES SIMPLEX VIRUS, TYPE 2, *IN VIVO* AND *IN VITRO*. L. Wright\* and P. Morahan. Dept. of Microbiology, MCV/VCU, Richmond, Va. 23298

The synthetic immunomodulator pyran copolymer and the killed vaccine of *Corynebacterium parvum*, a biologic immunomodulator, enhanced resistance to Herpes simplex virus, type 2, (HSV-2) infection in mice. Pyran, *C. parvum* and glycogen were administered intraperitoneally (IP) to BALB/c mice to define the role of immunomodulators with respect to antiviral activity of macrophages against HSV-2. Peritoneal exudate cells (PEC) from pretreated and control mice were explanted at concentrations of  $2 \times 10^6$ ,  $1 \times 10^6$  and  $5 \times 10^5$  cell/ml on mouse embryo fibroblast cell cultures infected with HSV-2. In contrast to glyco-gen, pyran and *C. parvum* stimulated PEC and decreased HSV-2 growth by one log<sub>10</sub>. When phagocytic cells were removed from pyran and *C. parvum* treated PEC populations, the antiviral activity of PEC was lost.

*In vivo* studies were conducted with mice treated IP with 40 mg silica two hrs prior to intravenous (IV), intravaginal (IVag) and IP challenges with HSV-2. Silica treatment enhanced the mortality of mice inoculated IV or IP, but had no effect on mortality of mice inoculated IVag with HSV-2. Phagocytic PEC appear to be involved in antiviral activity against HSV-2 and possibly in antiviral activity of pyran and *C. parvum* immunomodulators. (Supported in part by VCU Faculty Grants in Aid).

DEFECTIVE HERPES SIMPLEX VIRUS : BIOLOGICAL STUDIES, Susan S. Zenda\*, Byron K. Murray, Dept. of Microbiology, Medical College of Virginia, Richmond, Va. 23219

Defective interfering (DI) particles of herpes simplex virus, type 1, strain Patton, were generated by serial diluted passage in human epidermoid carcinoma cells (HEp-2). The presence of DI particles was monitored by a reduction in the titer of infectious nondefective (standard) virus and the appearance of a new viral DNA having a higher density ( $1.732 \text{ g/cm}^3$ ) in CsCl. The ability of DI particles to interfere with the yield of infectious standard virus in cell culture was shown to involve an early event in infection. The modulation of the course of infection by DI particles was examined using a mouse model.

## Section of Psychology

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

PERCEIVED LOCUS OF CONTROL AND LEVEL OF SUCCESS AS DETERMINANTS OF LEARNED HELPLESSNESS. Mark Albert\*, Nancy E. Miller\*, and E. Scott Geller. Dept. of Psychology, VPI&SU, Blacksburg, VA 24060.

The probability-learning performance of high and low scorers on Rotter's Internal-External scale was controlled by  $E$  at successful or unsuccessful levels (i.e., 80% versus 20% correct predictions). The successful externals and unsuccessful internals performed better than unsuccessful externals and successful internals in a subsequent serial learning task.

REPRESENTING WORD MEANING AND FACTUAL KNOWLEDGE. Nick Cercone. Department of Mathematical and Computing Sciences, Old Dominion University, Norfolk, Virginia 23508.

The research reported herewith is a development of some ideas concerning the representation of word meanings and of individual items of factual knowledge in a computer, where this knowledge is thought of as being conveyed to natural language. Many representational problems are examined, including the representation of states, events, and actions, complex concepts, adverbials, and comparatives. In addition to examining these problems, some concrete proposals are made to adequately depict their meaning structures (using a full quantificational apparatus).

Furthermore, the representation used for word concepts is explained. The nature of word concepts, whose meanings are represented as semantic networks, is explored and the computational use of these meaning representations is investigated within the framework of a natural language processing system.

THE EFFECTS OF IMMEDIATE AND DELAYED REINFORCEMENT ON IMPULSIVE RESPONDING. P. M. Cole\*. Dept. of Psychology, Col. of William & Mary, Williamsburg, Va. 23185

The effects of delayed and immediate primary reinforcement, and visual scanning and match-to-sample training, in modifying impulsivity in second-grade children were investigated. Response latencies and error scores on the Matching Familiar Figures Test were used to measure modification of impulsive responding. It appears that impulsive responding can become more reflective and modification procedures are discussed.

FREE-TIME MADE CONTINGENT UPON ON-TASK BEHAVIOR IN A SPECIAL EDUCATION CLASSROOM. J. V. Couch and T. H. Clement\*. Dept. of Psychology, Madison Col., Harrisonburg, Va. 22801.

Within the last decade numerous studies have demonstrated the effectiveness of structuring contingencies within the classroom to bring about desired pupil behaviors. In the present study, free-time was made contingent upon consistent on-task behavior for three trainable mentally retarded boys. An AB design was employed with fifteen minute time sampling being used for the Baseline (A) and Contingency (B) phases. During the contingency phase plastic chips were given to each boy for on-task behavior. The boy with the highest number of chips after the classroom work period was allowed to spend the longest amount of time in gym or outside the class. Differences between Baseline and Contingency data indicated an increase in on-task behavior. These results were discussed in terms of the Premack principle and escape conditioning.



A CASE STUDY IN THE HISTORY OF PSYCHOLOGY - C. L. FRIEDLINE. T.S. Shelton\* and Frederick B. Rowe, Dept. of Psychol., Randolph-Macon Woman's College, Lynchburg, Va. 24503

Corra Louise Friedline served on the faculty of R-MWC from 1918, the year she received her Ph.D. under Fitchner at Cornell, until her retirement in 1962. She continued to be active in psychology until her death in 1975.

Her career spanned nearly two-thirds of the century. In her teaching, research, and professional practice, her career reflects many of the major changes which have taken place in the practice of psychology, in the status of women in science and academic life, and in the waxing and waning of schools of psychology.

The material for the case study is drawn from the subject's academic records, from her notes and publications, from interviews with her former students and colleagues, and from taped recordings of her lectures in history of psychology courses.

RESISTANCE TO EXTINCTION FOLLOWING TRAINING WITH CONTINUOUS OR PARTIAL PUNISHMENT. R. A. Fulcher, Jr.\* Dept. of Psychology, Col. of William & Mary, Williamsburg, Va. 23185

Employing rats in a runway, the effects of continuous punishment and intermittent punishment on resistance to extinction of a positively reinforced approach response were investigated. As in previous studies, training with intermittent punishment plus continuous reinforcement increased resistance to extinction over continuous reinforcement alone; this effect was carried through a block of reinforcement-no punishment trials. Training with continuous punishment plus continuous reinforcement increased resistance to extinction over both intermittent punishment and reinforcement-alone conditions, and this effect also carried through a block of reinforcement-no punishment trials. Alternative explanations of these results, including sequential and counterconditioning models, were briefly considered. Current research to better discriminate between these theories was also discussed.

UNUSUAL RESPONSES AND OVERINCLUSIVE THINKING IN SUBGROUPS OF SCHIZOPHRENICS. D. M. Gilfoil\* Dept. of Psychology, Col. of William & Mary, Williamsburg, Va. 23185

The present investigation was conducted in an attempt to define which subgroup(s) of schizophrenics evince "overinclusive" thinking. Payne's Object Classification Test was administered to matched groups of 10 paranoid reactive, 10 nonparanoid reactive, 10 paranoid process, 10 nonparanoid process, and 10 normal subjects. Subjects were also grouped into high and low groups according to scores on the following scales of the Inpatient Multidimensional Psychiatric Scale: Perceptual Distortion, Disorientation, and Conceptual Disorganization. Results indicated that process patients (both paranoid and nonparanoid) evidenced significantly more overinclusiveness in sorting than reactive patients or normals. There were no differences observed between paranoid and nonparanoid subjects. In addition, patients scoring high on the Inpatient Multidimensional Psychiatric Scales measuring thought disorder, evidenced more errors than low scorers. Results were interpreted as suggestive of an alternative classification system for schizophrenic patients.

A GOOD BEHAVIOR GAME FOR THE REDUCTION OF INAPPROPRIATE CLASSROOM BEHAVIORS. Dana R. Hegerle\*, Mary Pat Kesercher\*, and J. V. Couch. Dept. of Psychology, Madison Col., Harrisonburg, Va. 22801.

The past few years have witnessed a preponderance of literature dealing with the development of contingencies to effectively manage disruptive classroom behavior. The present study examined the effects of individual contingencies for group consequences on disruptive classroom behaviors. Out of seat and talking out behaviors were studied in a classroom containing third, fourth, and fifth grade children. A good behavior game was constructed by first dividing the class into two teams. Out of seat and talking out behaviors were monitored with points being given for inappropriate behaviors. In this manner, a contingency was arranged for inappropriate behaviors of individual children while the consequences of the child's behavior was shared by all the members of his/her team. The winning team or teams were able to choose from an array of privileges and other reinforcers. Comparison between baseline and contingency data demonstrated a successful decrease in out of seat and talking out behaviors in the classroom.

BEHAVIOR ALTERATION OF BRAIN SEROTONIN LEVEL AS A FUNCTION OF OPERANTLY DECREASED DISRUPTIVE BEHAVIOR. M. B. Mendelson\*, J. Puckett\*, W. Ramey\*, Dept. of Psychology, George Mason University, Fairfax, Va. 22030

The major purpose is to test the hypothesis that a behavior modification program which reduces highly disruptive behavior produces an increase in brain serotonin level as measured by 5-HT concentration in blood platelets. The subjects are five adolescents aged 12 - 18 who are students at a private behavior modification school, and who meet criteria of both hyperdisruptive behavior and hypoconcentration of brain serotonin. Hyperdisruptiveness as measured by the "Disruptive Behavior Scale" demonstrates 70% convergence with hypoconcentration of brain serotonin.

Target behaviors are established and recorded to ascertain if a reduction in disruptive behavior is correlated with an increase in brain serotonin.

Program objectives are set as 50% decreased disruptive behavior in targeted behaviors. Preliminary results are promising for the continued use of behavioral methods to alter hyperdisruptiveness.

CAN THE DESIGN OF A TRASH CAN INFLUENCE LITTER-RELATED BEHAVIOR? Nancy Miller\*, Mark Albert\*, and E. Scott Geller. Dept. of Psychology, VPI & SU, Blacksburg, VA 24061.

A series of field studies were accomplished to determine the behavioral effects of special trash cans designed to prompt antilitter behavior. The two experimental trash cans were shaped like a bird, were painted in bright colors, and bore the antilitter message, "Please Be A Litter Bit Thoughtful". Each of the 4-ft. high bird receptacles were of the standard 50-gallon capacity; one took the appearance of a red cardinal and the other of an eagle (with a special bicentennial design).

Results indicated that the bird trash cans increased the probability that individuals would pick up and/or dispose of litter, but the advantages of the bird receptacles over standard trash cans varied considerably between environments (e.g., from 5% to 200% more litter disposals in the bird cans).

THE EFFECTS OF UNPLEASANT DISTRACTION UPON PERSUASION. J.S. Mottley\*, Dept. of Psychology, Madison Col., Harrisonburg, Va. 22801

Thirty-one students from two basic studies communication courses were exposed to a counter-attitudinal persuasive speech, advocating the abolishment of birth control methods and abortion. Along with the speech presentation, the students viewed a slide presentation of either a counterfeit college professor delivering a speech or scenes of war atrocities. Both the speaker and the speech were evaluated and an independent t test was used to analyze the data. The results indicated no significant difference for either the speech evaluation or the speaker evaluation.

These results demonstrated that unpleasant distractions inhibit persuasion. Under unpleasant distraction conditions, the attention of the listener is drawn away from the unpleasant stimuli and toward the speech content. In essence, the unpleasant stimulus loses its distracting impact and serves as an attention device for the speech itself. The opportunity for counterargumentation by the listener is enhanced. Unpleasant distractions do not reduce the opportunities for counterarguments. Therefore, the facilitating impact of distraction is thwarted and persuasion is inhibited.

EFFECTS OF PRECONCEPTION PARENTAL STRESS OF SEX RATIO IN JAPAN. Pamela L. Farnett, Dept. of Psychology, Col. of Im. and Mary, Williamsburg, Va. 23185

Relationships between pre-conception parental stress and litter sex ratio, weights, implantation rates, and litter size were explored. Stress consisted of confinement in wire cocoons prohibiting movement for 4 hours daily for 5 consecutive days. Piloerection, distress vocalization, excessive defecation and urination resulted from the stress procedure. Following the stress sequence, each male (stressed or non-stressed) was bred to 2 females (1 stressed/1 non-stressed). Females were killed on gestational day 20, the pups counted, weighed, sexed, and the number of corpora lutea and implantation sites recorded. The main effects of the stress appear to be an increased resorption rate when only the female is stressed and reduced litter size when both parents are stressed.

THE EFFECTS OF EXPOSURE TO HYPNOSIS AND VOLUNTEER STATUS ON ATTITUDES TOWARD HYPNOSIS. D. J. Ozer\*, Dept. of Psychology Col. of William & Mary, Williamsburg, Va. 23185

Students who volunteered for a hypnosis experiment were assigned to one of two treatment groups: one group received a hypnotic induction procedure, the other read a verbatim account of the induction regimen. Two no treatment control groups were composed of subjects who either did, or did not indicate a willingness to participate in a hypnosis experiment. Attitudes toward hypnosis were assessed by the author's questionnaire subsequent to any treatment, and hypnotic susceptibility was assessed in subjects receiving the induction. Results indicate that volunteer subjects have more favorable attitudes toward hypnosis than non-volunteers, and that exposure to hypnosis generally enhances this difference for most groups. Attitudes of less susceptible subjects in the induction group were an exception to this trend. Implications for the use of attitudes toward hypnosis as predictors of hypnotic susceptibility are discussed.

PRELIMINARIES AND PREFERRED FUTURES OF HUMAN PSYCHOLOGY IN INSTRUCTIONAL MODELING. W. E. Rowetson.

\* Dept. of Psychology, Madison Col., Harrisonburg, Va. 22801

Interest in instructional modeling grows, and educational researchers pose increasingly rigorous empirical questions about classroom learning. But what has been principally lacking are conceptual tools to compare one instructional position against its rivals. In classic sciences, theory serves this function, but, amidst instructional ideas and classroom concerns, there is sparsely little theoretical fabric.

The present paper posits eight target concerns and perhaps serves as a first-generation framework for comparing models. Several question an instructional model's image of man and include discussions of: man's multivariate nature; individual differences; holism; and blending usual questions of learning with developmental percepts. Remaining issues investigate the socio-political climate of American schooling; the desirability for instructional research to be decisive; empirically linking teacher training to subsequent performance; and the advisability of having instructional theory develop a distinct identity separate from learning theory.

DECISION AND REACTION LATENCIES IN A SOCIAL CONFORMITY PARADIGM. Catherine Wood\*, William Beatty\*, Steven McConnell\*, and E. Scott Geller. Dept. of Psychology, VPI & SU, Blacksburg, VA 24061.

The influence of another person's decisions on subject's decision making and information processing behaviors were studied. Choice strategies were reflected by the subject's stimulus predictions and by the latency between a stimulus presentation that represented another person's prediction and the subject's prediction. The influence of another person's prediction on the subject's expectancy for a stimulus was reflected by the latency between stimulus presentation and stimulus identification, i.e., choice reaction time. Decision latency and choice reaction time were studied as functions of the subject's decision competence (i.e., the number of correct stimulus predictions as controlled by the experimenter).

## Section of Space Science and Technology

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

AN EXPERIMENTAL INVESTIGATION OF UPPER SURFACE BLOWING.  
G. D. Catalano, J. B. Morton, and R. R. Humphris.  
Engineering Science & Systems, Univ. of Va., Charlottesville,  
Va. 22901.

An experimental investigation of the effects of a flap on the flow development of an axisymmetric jet exhausting into a moving airstream has been made. The jet/flap assembly used for this investigation corresponds to an upper surface blowing design presently being proposed as a possible V/STOL configuration by NASA - Langley. Of primary concern was the comparison between the flow fields of a freely expanding coaxial jet and the same jet but with the flap in place. Quantities measured in pursuit of this comparative investigation included mean velocities for all three dimensions, turbulent intensities, autocorrelations, power spectral densities and intermittencies. The investigation was confined to the near field of the turbulent jet in both instances (i.e. less than eight diameters downstream from the exit plane). A laser-Doppler velocimeter, using a phase locked-loop processor, was used to make the desired velocity field measurements. To determine the intermittency profiles, a laser light scattering technique was employed. (Work supported by NASA Grant No. NGR 47-005-219 and by NSF Grant No. ENGR 75-24488.)

IMPROVED PYROELECTRIC DETECTORS FOR REMOTE SENSING.  
R. K. Crouch,\* Langley Research Center, Hampton, Virginia  
23665.

NASA has an increasing interest in remote sensing of atmospheric constituents and thermal mapping of the Earth's surface from satellites or from aircraft. Experiments designed to make these measurements are currently plagued with infrared detector problems. Most infrared detectors operating in the 3-20 micrometer wavelength region have inadequate sensitivity or require complex and expensive cooling equipment. One promising approach to the solution of these problems is the pyroelectric detector. These detectors require no cooling which results in a savings in weight, size, and money. If these devices can be operated near their theoretical maximum sensitivity, they will satisfy numerous NASA detector requirements. NASA - Langley Research Center is initiating a program to improve pyroelectric materials and detector fabrication techniques in an effort to increase the sensitivity of these devices up to the theoretical maximum.

DEFINITION OF DIRECT SOLAR IRRADIANCE CONDITIONS FOR EXPERIMENTS ON THE LONG DURATION EXPOSURE FACILITY SATELLITE. Joseph M. Drewry,\* Aero-Space Technologist, NASA, Langley Research Center, Hampton, VA 23665

The Long Duration Exposure Facility (LDEF) is a NASA satellite designed to provide an easy and economical means for conducting experiments in the space environment utilizing the space shuttle for orbit placement and retrieval. LDEF is a reusable, unmanned, free-flying structure on which many different experiments can be mounted for exposure to the space environment for a nominal orbital mission duration of 6 months. A predictable, but non-unique direct solar irradiance history for each of 14 basic payload surfaces results from the passive 3-axis stabilization of the LDEF in the orbit plane. The actual solar radiation environment is dependent on the orbit parameters, launch time of year, and launch time of day. A technique will be described that has been developed to define the direct solar input to each surface in terms of the orbit geometry and variation in initial conditions. Typical normalized irradiance and extreme solar conditions expected on each surface as a function of time are presented.

Direct solar dosage per orbit is determined from integrating the irradiance time histories and is presented in terms of upper and lower bounds as a function of time of year. Application of the results to experiment selection and thermal control will also be presented.

DIFFUSION OF SMOKE IN AN ISOTROPIC TURBULENT FLOW.

M. Gad-el-Hak\*, and J. B. Morton. Dept. of Engineering Science & Systems, Univ. of Va., Charlottesville, Va. 22901.

Dispersion and detailed properties of the downstream evolution of smoke released in an isotropic turbulent flow field are reported. Effects of turbulence on the mass transfer characteristics of the flow which in turn affect such things as the spread of pollution and the rate of chemical reactions are studied. Smoke is released a short distance downstream of a uniform grid placed perpendicular to a uniform stream of air in a wind tunnel. A laser Doppler velocimeter is used to make the desired velocity field measurements, and a laser light-scattering technique provides the "instantaneous" mass fraction,  $c$ , of smoke at the same point in the flow field. One point statistical properties of the velocity and concentration fields are obtained, including mean values, rms fluctuations, autocorrelation, spectrum, probability distribution, and intermittency. The one point crosscorrelation  $W$  is also reported. (Supported by NSF grant ENG 75-24488.)

THE RESPONSE OF A TWO-DIMENSIONAL ZONALLY AVERAGED GENERAL CIRCULATION MODEL OF THE ATMOSPHERE TO DATA INSERTION WITH IMPLICATIONS FOR ENVIRONMENTAL REMOTE SENSING PROBLEMS. K. V. Haggard\* and R. E. Turner\*. Space Applications and Technology Division, NASA-Langley Research Center, Hampton, VA 23665.

Natural and manmade components of the Earth's atmosphere cause alteration to our environment. A zonally averaged circulation model has been developed which can aid in the formulation of optimum remote sensing strategies.

The climate as predicted by the model using an assumed distribution of the diabatic heating is compared with the Earth's climate. The model predicted climate, including an assumed source-sink distribution for a trace species, is used to generate data typically measured by satellites. The resulting data set is inserted infrequently in space and time into a model experiment where the diabatic heating and species source and sink terms are assumed unknown. The diabatic heating and the species sources and sinks are recovered by the experiment. These experiments imply the sensitivity of the model to insertion of infrequently sampled satellite data and the validity of various sampling strategies for satellite missions.

A CRITICAL ASSESSMENT OF THE SIMULATION TECHNIQUES IN CRASHWORTHINESS OF AUTOMOBILES AND AIRPLANES. M. P. Kamat\*, Dept. of Engineering Science and Mechanics, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Crashworthiness engineering is concerned with the optimal design of transportation vehicles that will maximize occupant survivability with minimal injury in potentially survivable crashes.

There are basically four approaches with which prediction of passenger trauma and evolution of improved design concepts are being currently explored. These are: (i) Full scale testing (ii) Hybrid simulation (iii) Scaled model testing and (iv) Mathematical simulation.

The author seeks to critically assess the potentialities of the mathematical and hybrid simulators in existence to date and those that are in the evolutionary stages of development. A vehicle crash is a dynamic phenomenon involving a complex interaction between structural and inertia behavior. A rigorous numerical analysis of such a complex phenomenon even if it could be made cost-effective with full scale testing may leave a lot to be desired with regard to the fidelity of simulation. Hybrid simulations and likewise the techniques of Scaled model testing appear to hold a lot of promise as a result of some good, though limited correlation with full scale testing.

MARC, DYCAST, ACTION, WHAM II and KRASH are among some of the simulators examined for their capabilities for prediction of the post impact response. (Aided by NASA grant NGR 47-004-114).

TOTAL ENERGY MANAGEMENT SYSTEM FOR A SINGLE FAMILY RESIDENCE. C. E. Kirby\*, R. C. Basford\*, NASA Langley Res. Ctr., Hampton, Va. 23665, H. R. Cuppett\*. Forrest Coile and Associates, Newport News, Va. 23666, W. H. Grover\*, Charles W. Moore and Associates, Essex, Conn. 06426.

Probably the most significant force for change in the residential building industry over the next few decades will be energy management. Homes consume approximately 20 percent of the energy used in the United States each year. Numerous studies have been prepared on energy management, and virtually all have recommended substantial changes in residential energy use patterns.

NASA's Langley Res. Ctr. is constructing a single-family detached residence to demonstrate the application of aerospace technology and to minimize the requirements for energy and utility services without significant changes in lifestyle. The project will emphasize technology which is expected to be commercially available in about five years. Parametric studies were made using a digital computer model of the house. A life cycle cost analysis approach was used in the selection and integration of energy/water systems in the house (model). The purpose of this paper is to present results of the design studies and economic analyses and indicate a combination of systems which may be widespread use five years from now. These systems would in an overall lower total owning and operating cost for the homeowner.

CRYOGENIC WIND TUNNELS--A NEW TECHNOLOGY WITH UNIQUE CAPABILITIES. R. M. Hall, Aeronautical Res. Scientist, NASA Langley Res. Ctr., Hampton, VA 23665.

During 1971 the Langley Research Center began to develop the cryogenic wind tunnel concept as a practical means for improving ground simulation of transonic flight conditions. Since that time, the Langley 1/3-meter transonic cryogenic tunnel has become operational and design of a cryogenic National Transonic Facility has been undertaken. A review of the very unique capabilities of cryogenic wind tunnels is now appropriate. Emphasis will be given to the flexibility of this new generation of wind tunnels becoming available to the scientific community. In particular, the advantages of having independent control of tunnel Mach number, total pressure, and total temperature will be highlighted. It will be shown that the separate control over the three tunnel parameters will open new frontiers in Mach number, Reynolds number, and aerodynamic studies. A brief status report on current research programs in the 1/3-meter tunnel will also be presented.

RECENT DEVELOPMENTS OF THE STEADY, UNSTEADY VORTEX-LATTICE TECHNIQUE INCLUDING LEADING EDGE AND TIP VORTICES. O. A. KANDIL, D. T. Mook, A. H. Nayfeh\* and E. H. Atta\*. Engr. Sci. & Mechanics Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24060.

A review of the recent developments of the vortex-lattice technique is presented. The method is applied to wings at high angles of attack in both steady and unsteady flows.

For highly swept wings, leading-edge separation is taken into account, and for small aspect, rectangular wings, wing-tip separation is taken into account. An iterative technique is used to make the wake force free and to satisfy the no-penetration boundary condition simultaneously. In all cases, the wakes are obtained as part of the solution. In the unsteady flows, vortex shedding and convection using the local velocities are considered.

The effects of compressibility and thickness are also included. Finally, the technique is extended to solve the problem of interacting lifting surfaces. The method is not restricted by the shape of planform, the aspect ratio, or the angle of attack (as long as vortex bursting or boundary-layer separation on the wing surface do not occur). For the unsteady flows, the method can be used to handle general unsteady flows. Thus, it is possible to treat rigid-body motions, wing deformations, gust effects and periodic motions. The numerical results and the experimental data are in good agreement. (Aided by NASA Grant NGR-004-090)

VISUALIZATION OF LOW REYNOLDS NUMBER FLOWS. C. A. Koromilas and D. P. Telonis. Dept. of Engr. Science and Mech., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Low Reynolds number flows are free of boundary layer or wake turbulence. As a result phenomena like separation and separated bubbles are stable and can be easily studied. Low Reynolds number flows were achieved experimentally with a 70% mixture of glycerin and water. Various visualization methods were tested. Our work indicated that the best method of visualization for such flows is the observation of surface pellets. An open channel was designed and constructed and tests were performed with a flat plate and a cylinder in order to check the reliability of the method. This was accomplished by comparison with previous experimental and theoretical data. The method was then used to study the response of laminar boundary layers over moving walls. In particular it was attempted to capture the saddle point configurations of separation as predicted by Moore, Rott and Sears.<sup>1</sup> The present results are in full agreement with the early conjectures on the topic as well as the theoretical predictions of Telonis and Werle<sup>2</sup> and Tsalhalis.<sup>3</sup> Some preliminary data on oscillating cylinders are also available. References: 1. Sears, W. R. and Telonis, D. P., *SIAM J. of Appl. Math.*, 28, 215-235 (1975). 2. Telonis, D. P. and Werle, M. J., *J. Appl. Mech.*, 40, 369-374 (1973).

3. Tsalhalis, D. Th., to be presented at the AIAA 9th Fluid and Plasma Dynamics Conference.

DECENTRALIZED AIRCRAFT CONTROL. Peter S. Lee and Dr. Hugh F. VanLandingham, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060.

The decentralized control system is characterized by the multiplicity of subsystems. Information must cross the boundaries between the subsystems. The aircraft control system structure which determines the interfaces and information distributions between the various subsystems is called an information pattern. Let  $P$  be a set of information patterns:  $P = \{P_1, \dots, P_m\}$ .

There is a cost  $C(P_i)$  associated with implementing each pattern; the cost function for the decentralized control system should be

$$J = J^0(P_i) + C(P_i) \quad i = 1, \dots, m$$

where  $J^0(P_i)$  is the optimal cost for fixed information pattern  $P_i$ . The trade-off between the implementation cost and the performance of the control system is emphasized.

DRAG REDUCTION IN SMALL AIRCRAFT. F. H. Lutz, Dept. of Aerospace and Ocean Engineering, VPI&SU, Blacksburg, Va. 24061.

The recent fuel shortage and the escalation of fuel costs have prompted the investigation of methods to reduce drag in the general aviation aircraft. Modern technology has also provided the possibility of introducing sophisticated control systems which can be incorporated into the early design of aircraft allowing a designer the possibility of matching vehicle aerodynamics with vehicle control. Unfortunately techniques for generating such a match are not available. The purpose of this paper is to investigate some techniques which may be used in conjunction with a control system to reduce the drag of a small aircraft.

The effect of c.g. location, downwash, zero lift pitching moment and neutral point on the lift and drag distribution between wing and tail are discussed with particular attention given to the location of the c. g. for minimum drag operation. It is shown that the location is sensitive to certain parameters such as the downwash at the tail. Some methods of designing for drag reduction are proposed.

INTERACTION BETWEEN SURFACE AND ATMOSPHERE OF MARS. D. B. Pierce,\* M. Gad-el-Hak,\* A. Howard,\* and J. B. Morton. Dept. of Engineering Science & Systems, Univ. of Va., Charlottesville, Va. 22901.

Photographs taken from the Mariner 9 spacecraft of the surface of Mars revealed the presence of eolian landforms closely resembling the desert dunes found on Earth. In order to study the characteristics of atmospheric winds and surface features of Mars, it was found that more information was needed concerning the effects of the Earth's desert boundary layer winds on sand dune formations. The barchan dune was selected as an interesting landform for study because it occurs as an isolated phenomenon and as the result of unidirectional winds easy to simulate in the laboratory; it also possesses the intriguing property of self-preservation of shape and size over time. A wind tunnel study is performed, wherein the Earth's boundary layer is simulated and scale models of barchan dunes are inserted. Measurements of velocity profiles around the models yield information about the flow pattern above the dune and the shear stresses on it, leading to information of the sediment budget for the barchan. (Supported by NASA grant NGR 47-005-172.)

SUMMARY OF 1975 OAST SPACE TECHNOLOGY WORKSHOP RESULTS. C. I. Tynan, Jr.\* NASA Langley Research Center, Hampton, VA 23665

The Workshop was sponsored by NASA's Office of Aeronautics and Space Technology (OAST) to aid in developing future OAST space technology programs to meet the needs of the scientific and applications "users" of OAST-developed technology. About 140 NASA personnel involved in planning, managing, and conducting space technology research programs participated in this intensive two-week effort at Madison College, Harrisonburg, VA, in August 1975. Basic research and multidiscipline technology experiments that can best be accomplished in space were identified and documented (published by Old Dominion University under NASA grant) in the disciplines of Data Processing and Transfer; Sensing and Data Acquisition; Navigation, Guidance and Control; Power; Propulsion; Structures and Dynamics; Materials; Thermal Control; Entry; Basic Research; and Life Support. Workshop results are presented in the form of major thrusts required in these technology disciplines to meet critical technology needs. The presentation highlights how the achievement of critical technology advances in disciplines such as sensors, instruments, structures, and materials can individually and collectively benefit investigative activities of the scientific community. A brief overview of Space Transportation System capabilities and Workshop organization is included.

USE OF WEATHER DATA TO PREDICT MOISTURE CONTENT IN RESIN MATRIX COMPOSITES. J. Unnan\* and D. R. Tenney\*, Materials Division, NASA Langley Research Center, Hampton, VA 23665.

The moisture absorption/desorption behavior of resin matrix composites can be mathematically described by classical diffusion theory using an effective diffusion coefficient. The appropriate diffusion equations have been solved by a finite-difference technique allowing for time dependent changes in the humidity and temperature of the environment. Simulations have been made for conditions of periodically increasing or decreasing humidity at constant temperature. Good agreement was found between calculated moisture content and literature reported data for T300/5208 epoxy composite. A weather bureau tape with hourly information for Langley Air Force Base was used to calculate the amount of moisture a T300/5208 composite panel would contain if exposed outdoors at Langley. Simulations were made for different thickness specimens using weather information averaged on an (1) hourly, (2) monthly, and (3) yearly basis. Calculations were also made to predict the time-dependent moisture content of a T300/5208 composite panel exposed to a "real-life" service environment for a commercial aircraft.

EARTH RADIATION MEASUREMENTS FROM ARTIFICIAL SATELLITES.

William L. Weaver\*, Aero-Space Technologist, NASA Langley Research Center, Hampton, Virginia 23665

Solar radiation is the energy source which drives the Earth's complex atmosphere-ocean system, and variations in the rates at which this energy is reflected, absorbed, and re-emitted by the Earth produce our climate changes. One of the World's leading climatologists has suggested that relatively small net gains or losses of solar energy by the Earth could result in significant alteration of the Earth's climate. It is essential, then, that we study the time and spatial variations of the Earth-Sun energy exchange and the processes which produce these variations.

Artificial Earth satellites are excellent platforms for monitoring the Earth-Sun energy exchange. Some techniques for making the required measurements are discussed, and some basic measurements made from two different satellites are presented. A method of inferring flux densities at the top of the atmosphere from the measurements is discussed, and some resulting flux densities are presented for one of the satellites. Some comparisons are made of flux densities obtained with two different instruments on the satellite, and the application of the results to other analysis techniques under development is discussed.

## Section of Statistics

Fifty-fourth Annual Meeting of the Virginia Academy of Science  
May 11-14, 1976, Fairfax, Virginia

SOME PROCEDURES FOR PROCESS CONTROL. S.T. Bakir\*, and M.R. Reynolds, Jr., Dept. of Statistics, VPI and SU, Blacksburg, Va. 24061

Groups of observations taken at regular time intervals on the output of a process are used to detect any shift in the process mean from a specified control value. If the observations indicate that a shift has occurred then the process is stopped so that rectifying action can be taken, but if the observations do not indicate any change in the mean then sampling is continued. Let  $(X_{1Y}, \dots, X_{nY})$ ,  $Y=1, 2, \dots$  be independent groups of iid observations made sequentially on the process. If  $R_{1Y}$  is the rank of  $|X_{1Y}|$  in the group  $\{|X_{1Y}|, \dots, |X_{nY}|\}$ , and  $\text{sign}(X_{1Y})=1$  when  $X_{1Y} \geq 0$  and  $-1$  otherwise,

then the test statistic is  $W_{nY} = \sum_{i=1}^n \text{sign}(X_{iY}) R_{iY}^k$ . This

statistic is used with a linear type boundary of the form "stop if  $W_{nY} \geq (h, h)$ ", and with a cumulative sum control type boundary of the form "stop if  $\max_{0 \leq m \leq n} W_{mY} - W_{nY} \geq h$  or if

$W_{nY} - \min_{0 \leq m \leq n} W_{mY} \geq h$ ." Using the Brownian motion process as an approximation to  $W_{nY}$  permits the average run length of the procedure to be evaluated analytically. A study on the effect of grouping is also made.

A SIMPLE METHOD OF COMPARING ALL PERCENTAGES AT THE .05 LEVEL. I. Selison\*, Res. Div. EEOC, Washington, D.C., 20506

Each type of percentage can be analyzed with little computation at  $\alpha = .05$ , by use of one of the following special tables of confidence limits.

(1) Zero Percent or no-occurrence percent table, with an upper 95% confidence limit, has  $N$  -- the total number of trials, cases, or people as the argument. The listed percent is used in place of the observed zero.

(2) Percents below one percent. The tables list U&L numbers (derived from  $\chi^2$ ) for various levels of  $\alpha$ , with the number of occurrences  $C$  as the argument. These numbers when divided by a large  $N \leq 500$  provide the limit. In addition, using this table, the maximum error can be calculated and used with the limits.

(3) Whole Percents. The percent allowance table lists the allowance  $A$  at the .025 level between  $P$  and  $P$ . The whole percent is  $P$  and  $N$  is total number of trials, cases, people, as the arguments. These  $A$ 's can be combined and used with the observed difference between the  $P$ 's,  $P_1$  and  $P_2$  to test for a significant difference at the .05 level

SOME SPECIAL PROGRAMS AND TECHNIQUES WHICH HELP TO TEACH CONCEPTS IN ELEMENTARY STATISTICS. J. V. Bowen, Jr., Mathematics Dept., University of Richmond, University of Richmond, Virginia 23173

An interesting method for computing  $\chi^2$  is given as part of an interactive (BASIC) program which generates multivariate data for student assignments. A sequence of problems is discussed which leads the student to a clearer understanding of correlation than is usually expected.

DEVELOPMENT OF OPTIMAL TREATMENT COMBINATIONS IN THE PRESENCE OF TOXIC SIDE EFFECTS. W. H. Carter, Jr., Dept. of Biostatistics and G. L. Wampler, Dept. of Medicine, Med. Col. of Va., Richmond, Va. 23298

In the treatment of cancer with combinations of chemotherapeutic agents, effective treatments often have associated serious side effects. A currently used method of finding "acceptable" treatments is to give doses in arbitrary ratios at a maximally tolerated level until side effects are present and then decrease the dose of each drug by a given percentage.

In this paper, we develop a method of finding treatments which maximize the probability of a favorable outcome while simultaneously limiting the frequency of toxic side effects. An example using a three drug combination in the murine L1210 leukemia model is presented.

## A PROCEDURE FOR OPTIMAL AUGMENTATION OF MINIMAL DESIGNS.

Wilkie W. Chaffin\* and Klaus H. Hinkelmann. Dept. of Quantitative Sciences in Business & Economics, Old Dominion Univ., Norfolk, Va. 23509 and Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

If the cost (in terms of time or money) of gathering data is very high, then a minimal multidimensional design (MMD) may be desirable when we wish to estimate all main effect linear contrasts under the usual additive model. If later information indicates that the assumed model (and thus the MMD chosen) is inadequate, then the design may be augmented to allow estimation of two factor interaction-type contrasts. If we use the minimum number of new assemblies, then the new design will be a minimal augmented multidimensional design (MAMD).

This work describes a procedure for finding an optimal MAMD. The S-optimality criterion (given by Shah (1960)) is used at each step during the stage of augmentation that allows estimation of the contrasts considered to be of primary importance. A design obtained in this manner will be called a sequentially S-optimal design. It is shown that determination of the first assembly to be added in this final stage will indicate how all assemblies should be added. Although use of the procedure is simplified for some special cases, it can be used in a variety of situations.

In the final section of this work, a comparison is made between the sequentially S-optimal design and the S-optimal design.

## AN EXPLORATORY STATISTICAL ANALYSIS OF OZONE IN THE STRATOSPHERE. B. G. Cox. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

The distribution of ozone in the stratosphere and the question of whether ozone is being affected by SST pollutants and aerosol sprays has aroused considerable interest recently. In this study, a time series analysis was performed on the monthly means of ozone from six North American stations. Results of this study indicated a very strong seasonal component to the variance of the time series. Positive trends were found in the data from four stations. Since ozone is formed by photochemical action and the time period of ozone observations was during a period of increasing sunspot numbers, this is suggestive of a relationship between the amount of ozone and the level of sunspot activity. Evidence was also obtained that agreed with earlier suggestions that ozone displays a biennial oscillation.

## SOME RESULTS ON THE PERFORMANCE OF ANALYSIS OF VARIANCE WITH DISCRETE DATA. S. L. Creve\* and R. H. Myers. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

This paper is a study of the problem of the adequacy of the analysis-of-variance procedure when the data is discrete. Much has been conjectured about the robustness of the analysis-of-variance in the case of nonnormal parents. The size and power of the one-way analysis-of-variance is studied using simulation for both the Poisson and the Negative Binomial parents. In addition, some previous robustness studies are reviewed.

## ISOTONICALLY SHRUNKEN ESTIMATORS OF REGRESSION FUNCTIONS. W. H. Fellner\*, Dept. of Biostatistics, Med. Col. of Va., Richmond, Va. 23298.

Monotonically decreasing shrinkage factors are applied to the least-squares regression coefficients in the case that regression variables enter the equation in fixed order, as in polynomial regression. The factors are obtained by minimizing a generalization of Mallows'  $C_p$  yielding biased regression coefficients of the James-Stein type. The resulting estimate of the regression function is smooth and squared-error consistent. By setting a parameter at the appropriate value, the probability is  $1 - \alpha$  of including no regression variables when all true regression coefficients are zero.

## ON THE UNIQUE CONSISTENT SOLUTION TO THE LIKELIHOOD EQUATIONS. R. V. Foutz\*, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

For some cases the maximum likelihood estimate of a single parameter may be taken to be a root of the likelihood equation. In these cases questions of the existence of a consistent root and of its uniqueness have historically been treated separately. In this paper, existence of a consistent root and its uniqueness are at once revealed by the same argument.

The corresponding existence and uniqueness problems for maximum likelihood estimates of vector parameters have been referred to as extremely difficult. The difficulty lies in extending the single parameter arguments to the vector case. The approach of this paper avoids these difficult problems by dealing directly with the vector parameter case rather than with extending single parameter arguments.

## THE POISSON DISTRIBUTION: THE THEORY AND APPLICATION OF SOME CONDITIONAL TESTS. J. J. Gatt\*, National Cancer Institute, Bethesda, Md. 20014

The Poisson distribution enjoys several convenient statistical properties. It is additive and complete; it possesses a sufficient statistic. Its exponential structure permits the construction of "exact" conditional tests. This paper discusses how these properties can be exploited in developing useful statistical methods. Part I contains the derivation of conditional tests of the Poisson based on the variance and the third and fourth sample cumulants. The "variance" test is also extended to case of left-truncated samples. In Part II significance tests for cross-product ratios of Poisson means are derived. All the methods are illustrated with practical examples in biomedical research.

AN EVALUATION OF THE RANDOM WALK HYPOTHESIS FOR THE SECURITY PRICE CHANGES DURING THE PERIOD 1964-1976. **P.M. Ghare\*** and **J.H. Lee\***. Dept. of IEOR, VPI & SU, Blacksburg, Va. 24061

A well known and widely accepted model describing the behavior of changes in security prices is the Random Walk model. In this model the variable "change in the price of a security" is assumed to have a p.d.f. with zero mean and zero serial correlation for any time lag. The form of the distribution is not explicitly stated but is widely held to belong to the Pareto family. Many studies were conducted during the early sixties which indicated the validity of this model. These studies involve two types of tests a) the autocorrelation of the time series of security price changes and b) the evaluation of trading results based on mechanical "filter trading" rules.

The time period covered by most of these studies included the great bull market of 1946-1965; consequently there was a bias in favor of "buy and hold" policies. The period from 1964-1976 would provide a better test period as the security markets have been in a trading range with no bias. This study includes the above 2 tests applied to the weekly price changes in a) Dow Jones Industrials, b) Standard and Poors 500 and c) five mutual funds. In addition a test to determine the non-Markov nature of the process is included.

EARLY HISTORY OF STATISTICS AND PROBABILITY IN AMERICA.

**Boyd Harshbarger**. Dept. of Statistics, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

This paper reviews the early developments of statistics in the United States with a short description of the early work at Iowa University and the University of Michigan. The period covered is from the years 1920 to 1944. The earlier contributors to statistical inference and methods for this period are given recognition. The development of statistical inference and methods in the South are noted with their special contributions.

A NEW PROCEDURE FOR STEEPEST ASCENT. **A. I. Khuri\***, and **R. H. Myers\***. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The method of steepest ascent is a maximum region seeking procedure which depends on approximating a response surface by a hyperplane in some restricted region of its independent variables. The path of maximum increase in the approximating linear response determines the path of steepest ascent. The standard procedure requires taking observations along the path until no additional increase in response is evident. The path is then abandoned, and a new series of experiments is conducted along a new path. This procedure is inefficient in the sense that it may stop prematurely when the true mean response is still increasing. A new stopping rule is introduced in terms of two stopping bounds,  $a$  and  $b$ , whose values are determined by two criteria: 1-If the true mean response is increasing along a certain path, then as many observations as possible should be taken before a decision to stop is made. 2-If the true mean response is decreasing, then the number of observations taken along the path should be minimal. The new procedure is more powerful than the standard one in its quickly detecting a real drop in response, and minimizes the number of tests needed in the search for the region of maximum response.

THE USE OF Q-TECHNIQUE FACTOR ANALYSIS IN JUDGE SELECTION. **R. Korb**. Sch. of Ed., American Univ., Washington, D.C. 20016.

The use of Q-technique factor analysis solves two fundamental problems inherent in the selection of individuals for any judgmental task. It establishes, a priori, those individuals who will have interjudge agreement when judging identical products or performances. It also delineates those criteria which homogeneous judges consider important in the evaluation of a product or performance.

The methodology involves several steps: (1) defining generalized criteria which are relevant to the judgmental task; (2) obtaining potential judges' ratings of these criteria either through a Q-sort or a Likert scale; (3) factoring the matrix composed of intraclass correlations between pairs of judges (Q-technique factor analysis) which results in sets of judges who have homogeneous perceptions of the criteria; (4) determining the score of each criterion on each factor, i.e. each set of homogeneous judges, which reveals those criteria that a particular set of judges considers important.

The method was applied to two samples of potential judges of creative products in art, science, music, and literature and was found to have excellent internal and external validity.

EXACT CALCULATION OF CERTAIN F PROBABILITIES. **M. Lentner\***, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061.

The F distributions are widely used in statistical inferences concerning the variances of two normals, analysis of variance procedures, multiple regression analyses, simultaneous interval estimation, and so on. Percentiles or probabilities of F distributions are required in these inferences.

Various approximate procedures have been employed in the calculation of cumulative probabilities of F distributions. Most, if not all, of these approximations perform poorly for small degrees of freedom and/or for extreme tail areas.

A series of closed form expressions has been developed for the exact calculation of F probabilities. For small degrees of freedom, calculations can be performed with standard mathematical tables and a good calculator. For larger degrees of freedom, a computer would be used. An APL computer program has been written to perform the calculations according to the exact expressions. Accuracy of results from this program is limited only by the properties of the APL system which includes the use of double precision arithmetic.

CLUSTER SAMPLING IN A FINITE POPULATION UTILIZING A SUPER POPULATION CONCEPT. **R. B. Madden**. Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061

In a finite population where the elements are grouped in  $N$  clusters let  $y_{ij}$  be the value of the  $j$ th element in the  $i$ th cluster;  $i=1, \dots, N$ ;  $j=1, \dots, M_i$ . The objective is to

estimate the total  $T = \sum_{i=1}^N \sum_{j=1}^{M_i} y_{ij}$  using a two-stage

sampling process whereby one first selects a sample of  $n$  clusters, and then a selection of  $m_i$  elements from each of the  $n$  clusters is made. Furthermore, known values of an auxiliary variable  $x_i$  are given for each of the  $N$  clusters. The elements are assumed to follow the model

$y_{ij} = \beta \frac{x_i}{M_i} + e_{ij}$ . The BLUE of the total  $T$  is obtained and

compared to the conventional estimator.



REFINEMENTS IN POPULATION ESTIMATES FOR VIRGINIA LOCALITIES. J.H. Martin\*, and W.J. Serow. Tayloe Murphy Institute, Colgate Darden Graduate School of Business Administration, University of Va., Charlottesville, Va. 22906

In a number of states, including Virginia, the most accurate of the methods in use for the production of intercensal estimates of the populations of counties and independent cities is the regression method. This method uses four population indicators, school enrollment, state tax returns, births, and employment to derive regression coefficients in the Census year. These coefficients are commonly derived on a state-wide basis and are applied to the variables in a prediction equation in order to produce the county and independent city estimates for the intercensal years.

The authors are engaged in research which indicates that the accuracy of the county and city estimates might be improved by stratification; that is by deriving regression coefficients within certain groups of counties and cities rather than for the state as a whole. Non-white population, degree of urbanization, and prior growth rates are among the criteria for such stratification. Since population estimates are used by a number of private and public agencies within the state for a wide variety of planning-related purposes, improvements in the accuracy of estimation would be of considerable use.

FACTORIAL DESIGNS FOR DETECTION OF MODEL INADEQUACIES.

Max D. Morris and T.J. Mitchell\*. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060 and Union Carbide Corp. POB-7, 9704-1, Oak Ridge, Tenn. 37830

The experimental situation of interest is the case in which a linear main effects model is assumed to be correct, and a design is to be formulated for: 1) estimating the grand mean and main effects, and 2) testing the assumption that all two-factor interactions are negligible. The "Lack of fit" statistic (regression sum of squares for two-factor interactions given main effects and mean) is used for the test. Designs are derived by maximizing the value of the non-centrality parameter of this statistic, averaged over some set of possible non-zero values of the two-factor interactions.

An upper bound for the optimality criterion is derived. The upper bound is attained by a design if and only if it is orthogonal and of resolution IV. Minimal design sizes for orthogonal resolution IV designs are found. For  $2^k$  experiments, a set of near-optimal designs are described for design sizes for which orthogonal resolution IV designs do not exist.

THE EFFECT OF SPATIAL DISTRIBUTION ON A CLASS OF PROBABILITY PROPORTIONAL TO SIZE SAMPLING ESTIMATORS. R.G. Oderwald\*, Dept. of Forestry and For. Prod., VPI&SU, Blacksburg, Va. 24061

A general model is developed to compare the efficiencies of p.p.s. sampling estimators for sampling elements in two dimensions arranged in clumped random, completely random, and square lattice spatial patterns. The clumped random and the random patterns are represented by the negative binomial and Poisson Distributions, respectively. Sampling in the lattice pattern is developed using Diophantine equation results.

Population elements are selected for sampling with probability proportional to  $u^k X$ , where  $u$  is a constant and  $X$  is an element characteristic. An estimator of the total per unit and its variance are developed. The estimator is unbiased in all spatial patterns considered.

The general model is specialized for estimating total basal area per acre for forest stands. The variances for the three patterns are ordered, largest to smallest, as clumped random, random, and lattice. The clumped random and random p.p.s. variances are smaller than their equal probability counterparts, while the reverse is true for the lattice variances. The variance formulations can also be used to demonstrate the effect of the size distribution of  $X$ , and, with a cost function, the number of sampling elements and the constant  $u$  may be determined for a given situation.

SOME RESULTS IN THE ESTIMATION OF SURVIVAL PARAMETERS.

Karl E. Peace\* and Roger E. Flora. Dept. of Biostatistics, Med. Col. of Va., Richmond, Va. 23298

Cox, in his 1972 paper, "Regression Models and Life-Tables", considers the hazard function,  $\lambda(t) = \lambda_0(t) \exp(\mathbf{x}_i^T \boldsymbol{\beta})$ , where  $\mathbf{x}_i$  is a vector of concomitant measurements on the  $i^{\text{th}}$  individual. By conditioning on the set of instants at which failures occur, he is able to assume  $\lambda_0(t)$  arbitrary. The resulting maximum likelihood estimation of  $\boldsymbol{\beta}$  is thus maximum conditional likelihood and the estimate,  $\hat{\boldsymbol{\beta}}$ , is not time dependent. Since no distributional assumption concerning  $t$  is made, the method of estimation is distribution free.

In this paper, Cox's form of  $\lambda(t)$  is assumed and  $\lambda_0(t)$  is specified by the constant, Weibull, Rayleigh, and Gompertz hazards. This creates four failure density models.  $\boldsymbol{\beta}$  is estimated in each of the models by the method of maximum likelihood. Tests of hypotheses concerning  $\boldsymbol{\beta}$  are then considered. The test statistics are generated from each model and Cox's approach by the likelihood ratio criterion and the asymptotic normality property of maximum likelihood estimators. Finally an efficiency comparison is made between the tests arising from Cox's approach and the tests arising from each of the four models for the above hypotheses. As applications, a Kidney transplant data set and the data set considered by Feigl and Zelen (1965) are analyzed.

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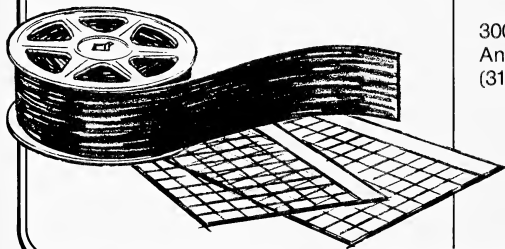
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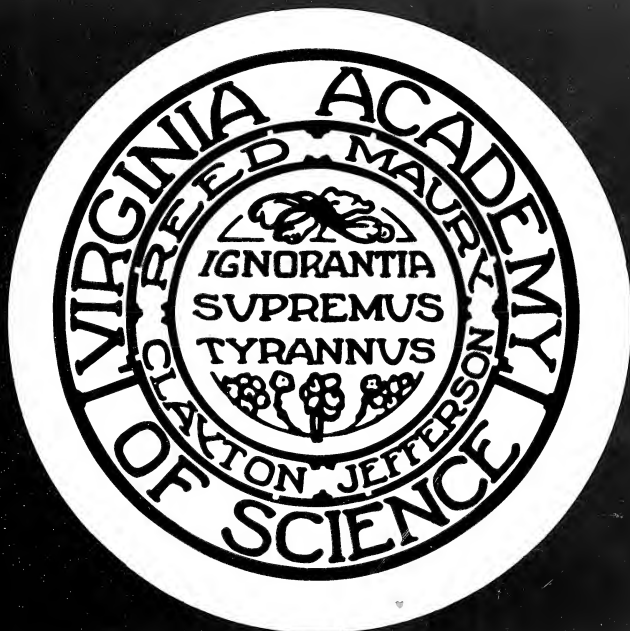
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# VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE





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VIRGINIA ACADEMY OF SCIENCE

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Vol. 27

No. 3

Fall 1976

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# THE VIRGINIA JOURNAL OF SCIENCE

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Official Publication of the Virginia Academy of Science

EDITOR

DAVID A. WEST

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Temporarily Vacant

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Published quarterly by The Virginia Academy of Science, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061. Second-class postage paid at Richmond, Virginia.

With the 1977 volume of the Journal the Editorship passes to Dr. Kuldip P. Chopra of Old Dominion University. All editorial correspondence should be sent to Dr. Chopra, whose full address is given below.

Manuscripts for publication (other than section abstracts) should be sent to the Editor, Dr. Kuldip P. Chopra, Arts and Letters Building, Room 502, Old Dominion University, Norfolk VA 23508. Proof, edited manuscripts, and all correspondence regarding accepted papers should be sent to the Editor.

Advertising and Business Office: All correspondence relating to advertising and business affairs should be directed to Business Manager, Virginia Journal of Science, c/o Department of Biology, V.P.I. and S.U., Blacksburg Va. 24061.

The Virginia Academy of Science and the Editors of the Virginia Journal of Science assume no responsibility for statements or opinions advanced by contributors.

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Subscription rates for 1976: \$10.00 per year, U.S.A.; Canada and other countries of the Pan-American Union, \$10.50 per year; all other foreign countries, \$11.00 per year. All foreign remittances must be made at par U.S. dollars or the foreign equivalent. U.S. dollar remittance is suggested to avoid currency fluctuation problems and possibly unfavorable exchange rates.

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Manuscript accepted November 15, 1976

## Man and the Great Dismal

### I

Captain John Smith, in September 1608, came very close to being the discoverer of one of the unusual features of this newly settled land. In June of that year he had recorded the discovery of the Nansemond River. Now, wishing to become better acquainted with his new neighbors, he sailed up the river with twelve of his men. He did not find the neighbors very hospitable, and after a skirmish with them some seven or eight miles up the river, he turned back. Had he been able to explore around the headwaters of that river, he might have been the first white man to discover what later came to be known as the Great Dismal. He did not do so, and no record has been found to make clear that any one person eventually did.<sup>1</sup> Sir Thomas Dale must also have come close to the discovery four years later when he too explored the Nansemond.<sup>2</sup> The Indians had, of course, long known it well as a hunting ground. The Great Dismal is not an easy place to explore today, even in the absence of inhospitable Indians, and the early settlers may well be excused if they tended to avoid it. Even in 1670 the map maker Augustine Herman described the area as "for the most parts Low Suncken Swampy Land not well passable but with great difficulty and therein harbours Tygers Bears and other Devouring Creatures."<sup>3</sup>

It is probable that the early settlers, surrounded by unexplored forest, only gradually became acquainted with the extent and character of the Great Dismal, and that it had no single discoverer. Small swamps, or *dismals*, as they were then called, were commonplace in Tidewater Virginia and North Carolina. They were, naturally, places to be avoided. Eventually the settlers became aware that one of these was

not small but covered a vast area. Its full extent was considerably greater then than it is now, and even today estimates of its extent vary between 250 and 750 square miles.<sup>4</sup> The Great Dismal extends southward from the headwaters of the Nansemond River, near Suffolk, Virginia, across the North Carolina-Virginia boundary line to the area just north of Elizabeth City. Its limits are nowhere sharply defined, and hence the widely varying estimates of its total extent. Portions of it have been the subject of a great many surveys since 1608, but there has never been occasion for a survey of the entire swamp *per se*.

The Great Dismal not only seems to have had no single discoverer, but its early history is extremely fragmentary. Settlers were naturally attracted by land which could be exploited with less effort and there was plenty of it. Gradually land was patented on the fringes of the swamp and its outlines became more-or-less apparent. Livestock, living off the land, were tempted by the lush growth of the swamp and drew attention to it. Wild animals which had provided good hunting in the swamp before the coming of the white man, tended to be driven there more and more by his activities, and attracted white hunters as well as Indian. But the vast unexplored lands west of the early settlements provided greater attraction with less effort, and the Great Dismal was not involved in any events which have left a record for quite a number of years.

Students of the early Indian tribes of this region seem agreed that none of them lived in the swamp except on temporary hunting expeditions.<sup>5</sup> There were, however, a number of tribes in the surrounding area which relied on the hunting there and left behind many "arrowheads, knives, and hatchets" for white explorers to discover.<sup>6</sup> Captain John Smith listed twenty-eight tribes as being under the control of Powhatan. One of these was the Nansemond tribe which attacked Smith and his men. This was a rather large tribe with a population estimated to number 750. Their principal village was located near the present

<sup>1</sup> Edward Arber and A. G. Bradley, eds., *Travels and Works of Captain John Smith, President of Virginia and Admiral of New England* 2 vols. (Edinburgh, 1910), I, 31; II, 430-31.

<sup>2</sup> F. Roy Johnson, *Tales from Old Carolina* (Murfreesboro, N.C., 1965), p. 12.

<sup>3</sup> Emerson D. Fite and Archibald Freeman, *A Book of Old Maps* (Dover Publications, New York, 1969), pp. 151-52.

Editor's Note: This article was written in 1973 at the request of the chairman of the Publications Committee, to serve as the introductory chapter of a proposed volume on the Dismal Swamp.

<sup>4</sup> Thomas E. Freston, "The Great Dismal Swamp—a Gift to the Nation," *Contact*, one/73, Vol. 8, No. 1, p. 21.

<sup>5</sup> Johnson, *Tales*, pp. 1-10.

<sup>6</sup> C. F. Stansbury, *The Lake of the Great Dismal Swamp* (New York, 1925), p. 25.

town of Chuckatuck.<sup>7</sup> On the North Carolina side of the swamp John White's map of the 1585-1588 period, shows the areas south of the Great Dismal as belonging to the "Chawanook" Indian tribe. Thomas Harriot who, like White, was a member of the first colony sent by Sir Walter Raleigh to Roanoke Island in 1585, gave some account of the Indians in this area. So, too, did Ralph Lane, who was left in charge of the colony by Sir Richard Grenville.<sup>8</sup> There is an unauthenticated account of an expedition from Jamestown to parts of the Chowanook area by a Captain Argall in 1610. John Pory, Secretary of the Virginia colony, definitely did lead such an expedition in February 1622. He apparently used an Indian trail skirting the swamp on the west, and did not travel through the swamp itself.<sup>9</sup>

Although the Indian massacres of 1622 and 1644 and the hostility of the Indian tribes generally retarded exploration and settlement for a number of years, the Indians were gradually pushed back from the coastal areas and settlements developed both south and west of the Great Dismal. In 1629, Charles I granted a patent to Sir Robert Heath of land called the "Province of Carolana," lying between thirty-one and thirty-six degrees north latitude.<sup>10</sup> Neither Heath, nor the Duke of Norfolk to whom he assigned the grant, carried out plans for establishing a colony. Thus it was left for hunters and those trading with the Indians gradually to explore this territory south of the Great Dismal. In 1655 one William Wright was given a patent to 2250 acres of land in the swamp.<sup>11</sup> Some people made purchases of land from the Indians, a practice forbidden by Virginia in 1662.<sup>12</sup> Finally, in 1663, a proprietary grant was made by Charles II to eight prominent men of all land lying between thirty-one and thirty-six degrees latitude and extending westward to the South Seas. The charter granted the men broad powers to settle, develop and govern the area.<sup>13</sup>

The new proprietors had their grant contested by the Duke of Norfolk but his claim was disallowed on the grounds that no settlement of consequence had been made during the thirty-four years since the grant to Heath by Charles I. This no doubt gave encouragement to the new proprietors to avoid the same pitfall. They soon developed plans for three "counties," the northernmost of which was to be Albemarle, including the Chowan-River-Albemarle Sound area south of the Great Dismal.<sup>14</sup> Settlement began to increase in the Albemarle region although its growth was not spectacular. Virginia had already made a number of grants in the area lying between the Great Dismal and the thirty-sixth parallel.

There were, at this time, two principal roads be-

tween the Carolina settlements and the Norfolk area. One ran due north from Edenton to Suffolk, skirting the western edge of Great Dismal, and from there one could travel by road or by ferry. Another ran from Edenton to Great Bridge to the east of the Great Dismal, "where were clustered warehouses and a wharf or two. One could see two-wheeled carts from the Dismal Swamp, or the Pasquot region, or even from Currituck, unloading their barrels of tar, turpentine, or pitch, or their bundles of shingles, or hogsheds of tobacco." Carolina herdsmen drove large numbers of cattle and hogs to Norfolk markets.<sup>15</sup>

As early as 1664 there were enough settlers in Carolina to justify the appointment of a governor. The proprietary board ordered Sir William Berkeley, Governor of Virginia and also one of the eight proprietors for Carolina, to appoint one, or to recommend his appointment. His choice was William Drummond "a sober Scotch gentleman of good repute." The beautiful lake in the Great Dismal appears to have been named for him. There is an unauthenticated tradition that he discovered it while on a hunting expedition during which his companions were lost and failed to return. He served as Governor of Carolina until 1667.<sup>16</sup>

In 1665 the Carolina proprietors received an extension of their grant northward from the thirty-sixth parallel: "from the north end of Currituck river or inlet upon a strait western line to Weyanoke Creek which lies within or about the degrees of 36 and 30 minutes northern latitude; and as far west, in the direct line, as far as the south seas."<sup>17</sup> To some this seemed to add to Albemarle all land between Albemarle Sound and the Great Dismal, as well as a substantial part of the swamp itself. Almost immediately complications arose concerning this added strip of land. There was no general agreement concerning the actual location of the new line separating Virginia from Carolina. Settlers in the region who had received their grants from Virginia and paid quit-rents to her, began to take advantage of the doubt and to refuse further payment of quit-rents. When the Virginia Council eventually ordered the Sheriff of Lower Norfolk County to take the necessary steps to collect the rents, he met with stiff resistance. In at least one case he arrived at a house to find it defended by eighty armed men. These settlers on the frontier were a ruggedly independent breed. Many of them had settled there to escape from the irksome controls of both church and state. They were equally reluctant to comply with Carolina regulations concerning such matters as trade with the Indians.<sup>18</sup>

Even those settlers whose land was definitely on the Carolina side of the boundary line had problems with Virginia. They depended heavily on her for marketing their crops of corn and tobacco. The harbors of Carolina were not adequate for vessels of any size. As

<sup>7</sup> Ben C. McCary, *Indians in Seventeenth Century Virginia* (Williamsburg, 1957), p. 1.

<sup>8</sup> Thomas Harriot, *A Briefe and True Report of the New Found Land of Virginia* (Dover Publications, New York, 1972), p. 42; Richard L. Morton, *Colonial Virginia* 2 vols. (Chapel Hill, 1960), 1, p. 3.

<sup>9</sup> O. T. Burck, Jr., and Hugh T. Lefler, *Colonial America* (New York, 1958), p. 156.

<sup>10</sup> *Ibid.*

<sup>11</sup> The Dismal Swamp Land Company Papers, Duke University, subsequently referred to as DSLC-DU.

<sup>12</sup> Burck and Lefler, *Colonial America*, p. 157.

<sup>13</sup> *Ibid.*, pp. 157-59.

<sup>14</sup> *Ibid.*, p. 159. Further south were Clarendon in the Cape Fear Valley and Craven in present day South Carolina.

<sup>15</sup> Thomas J. Wertenbaker, *Norfolk, Historic Southern Port* (Durham, N. C., 1962), pp. 33-34.

<sup>16</sup> Morton, *Colonial Virginia*, 1, 247; Alexander Crosby Brown, *The Dismal Swamp Canal* (Norfolk County Historical Society of Chesapeake, 1970).

<sup>17</sup> William K. Boyd, ed., *William Byrd's Histories of the Dividing Line between Virginia and North Carolina* (Dover Publications, New York, 1967), p. xxix.

<sup>18</sup> *Ibid.*; William L. Saunders, ed., *The Colonial Records of North Carolina* (Raleigh, 1886), 1, 364-65.

early as 1679 Virginia was attempting to limit tobacco production within the state and forbade the shipment of Albemarle tobacco through her ports. This left the Carolina growers to the tender mercies of New England ship captains, and the growers were understandably bitter. Virginia officials tended to regard the Carolina settlers as persons evading the laws and gave them little sympathy. Thus, early in the day, there was friction and hard feeling between the two colonies.<sup>19</sup>

The necessity for a survey to determine the actual boundary between them became apparent to many in both colonies soon after the second grant was made to Carolina in 1665, but it was slow in realization. The proprietors of Carolina petitioned the Committee for Trade and Plantations in 1681 to require Virginia to appoint a commission to meet with representatives from Carolina. If the Committee took any action, there seems to be no record of it. Thomas Milner, surveyor for Nansemond, Princess Anne and Norfolk counties, was sent with Philip Ludwell, governor of that part of Carolina north of Cape Fear in 1690, to make surveys. He later referred to having notes concerning the boundaries of the second grant to the proprietors and was ordered to send such notes concerning the "pretended grant" to the Virginia Lieutenant Governor and to the Clerk of the Council at James City.<sup>20</sup>

Since Virginia was skeptical of the validity of the second grant, the proprietors sent a copy of the 1665 charter to Deputy Governor Harvey of Carolina in 1697 in support of their claim. Finally, in 1699, Harvey received an official order from the Crown to appoint a commission to establish the boundary line. He promptly appointed commissioners and sent them to Williamsburg only to have them rejected by the Virginia Council on the grounds that Harvey had not been legally named governor.<sup>21</sup>

Virginia was not going to yield territory without protest. In 1701 Governor Nicholson recommended to the Lords of Trade that all of Carolina be restored to Virginia. When nothing came of this, Virginia finally ceased to oppose the determination of the boundary line. It was decided, however, to run a secret survey of their own before beginning negotiations with Carolina. Word of this reached Carolina and she, too, decided to run a preliminary survey. In 1709 the Lords of Trade recommended the appointment of a joint survey and, for the first time, both colonies favored the idea. Commissioners were appointed in 1710, Edward Moseley and John Lawson for Carolina and Nathaniel Harrison and Philip Ludwell for Virginia. Controversy soon arose among the commissioners, primarily over the identity of Weyanoke Creek and the accuracy of the instruments. It became evident that a compromise was the only solution and one was agreed upon by Governor Eden of Carolina and Governor Spotswood of Virginia in 1715. This might have seemed to be the last obstacle but approval of the Crown was required and it was

not obtained until 1727. At long last, in 1728, a new joint commission was appointed. From Carolina came Christopher Gale, Edward Moseley, William Little and John Lovick. Virginia commissioners were William Dandridge, Richard FitzWilliam and William Byrd. The surveyors for Carolina were to be Moseley and Samuel Swann, for Virginia Alexander Irvine and William Mayo.<sup>22</sup>

Our first description of the Great Dismal, as well as our knowledge of the details of the actual survey of the line, is found in William Byrd's accounts. One of these, *The History of the Dividing Line betwixt Virginia and North Carolina run in the year of our Lord 1728*, was apparently completed in 1738 and was intended for publication. The other, *The Secret History of the Line*, seems to have been written earlier and intended for limited circulation, not publication. Neither account was published until much later and neither is to be confused with Byrd's journal and survey notes which were sent to the Board of Trade.<sup>23</sup> Byrd was a fascinating character familiar to many readers who have enjoyed his secret diaries, his correspondence and other writings.

Several William Byrds have been prominent in Virginia history and are easily confused. Our concern is with William Byrd II, and his histories of the dividing line. His father, William Byrd I, came to Virginia from London as a young man associated with an uncle, Thomas Stegg, a very successful merchant and Indian trader. He inherited the business and land from Stegg and added to his wealth by his own activity and by marriage. He was prominent in public affairs, a member of the House of Burgesses, member and President of the Executive Council, and Auditor of Virginia. William Byrd II (1674-1744) was sent at the age of seven to begin his education in England. He received a thorough classical education and studied law for three years at the Middle Temple. He also spent some time with merchants in Holland and with the firm of Perry and Lane, his father's agents in London.<sup>24</sup>

After a prolonged absence from Virginia, Byrd returned there in 1695. He remained briefly, long enough to be elected to the House of Burgesses, but was soon asked to return to England as legal representative of the Virginia Assembly. Little persuasion was required since he loved the gay life of London, both social and intellectual. Some indication of his intellectual attainments may be had from the fact that he was elected, at the age of twenty-two, to membership in the Royal Society of London, then as now, one of the most prestigious scientific societies in the world. He remained in London until 1704 when the death of his father necessitated his return to Virginia. He was elected to the Council and appointed Receiver-General for the Crown. In 1715 he once more sailed for England, this time to represent the colony with the Board of Trade. He did not return to Vir-

<sup>19</sup> *Ibid.*, pp. xxx-xxxii. John Lawson, a member of the earlier commission had since been barbarously murdered by Indians.

<sup>20</sup> *Ibid.*, p. 29; H. R. McIlwaine, *Journals of the House of Burgesses . . . 1659/60-1693* (Richmond, 1914), p. 199. The appointment of Ludwell in 1690 seems to have been the first recognition of a North and a South Carolina. It did not become fully official until 1712.

<sup>21</sup> Boyd, ed., *Byrd's Histories*, pp. xxix-xxx.

<sup>22</sup> Thomas Jefferson is said to have interested the American Philosophical Society in publishing Byrd's two accounts of the survey, but the Society decided against doing so because of Byrd's frequent and frank references to sex (*ibid.*, p. xxi). The *History* was published by Edmund Ruffin in 1841 and the *Secret History* by William K. Boyd in 1929.

<sup>23</sup> Percy G. Adams, "Introduction," Boyd, ed., *Byrd's Histories*, p. vi.

ginia until 1726. Thus, when he undertook to head the Virginia contingent in determining the dividing line, he was fifty-three years old, had spent most of his life in England, and had been back in Virginia only a year.<sup>25</sup>

Prior to meeting to begin the actual survey, the Virginia and Carolina commissioners exchanged letters concerning equipment needed and probable problems to be encountered. The North Carolina commissioners raised the issue of the Great Dismal: "You will let us know, after what Manner you propose to run the Line, whether you think to go thro' the Great Swamp, which is near 30 miles thro', & thought not passable, or by taking the Latitude at the first Station to run a due West Line to the Swamp & then to find the said Latitude on the West Side the Swamp, & continue thence a due West Line to Chowan River."<sup>26</sup> Governor Everard had suggested to them in his instructions that they might find it necessary to make a traverse around the Great Dismal. The Virginia commissioners agreed that it might prove necessary to survey around the swamp.<sup>27</sup>

The commissioners and the survey party met at Currituck Inlet and, after some preliminary argument concerning the starting point, began the actual survey on March seventh. They did not reach the Great Dismal until the fourteenth. It had taken a week to cover the few miles from the coast and they had struggled through mire and marsh all the way. In at least one place they found the going impossible and made a short traverse. Rugged as the going had been, they were all well aware that the worst was yet to come.<sup>28</sup>

It would seem that there might well have been unanimous agreement to traverse around the Great Dismal and that they might have done so with clear consciences. There was, however, no disposition to do so, either on the part of the commissioners directing the operation or the surveyors and their helpers who were carrying it out. They made inquiries of the settlers living nearby but found it "hardly credible how little the Bordering inhabitants were acquainted with this mighty Swamp, notwithstanding they had liv'd their whole lives within Smell of it. Yet, as great Strangers as they were to it, they pretended to be very exact in their Account of its Dimensions, and were positive it could not be above 7 or 8 Miles wide, but knew no more of the Matter than Star-gazers know of the Distance of the Fixt Stars. At the Same time they were Simple enough to amuse our Men with Idle Stories of the Lyons, Panthers and Alligators, they were like to encounter in that dreadful Place."<sup>29</sup>

It was apparent to Byrd and his fellow commissioners that anything to be learned about the Great Dismal they would have to learn for themselves. The complete lack of knowledge concerning it convinced them that they should not by-pass it. They therefore decided against a traverse around and determined to survey straight through. It was decided to send all of the surveyors and twelve men to assist them. The

commissioners would skirt the swamp and meet them on the opposite side. The latter were not merely evading the dirty work. They had concluded that they would only add to the burdens of the work party without being of any great assistance to them if they went along.<sup>30</sup> Neither should it be inferred that the survey party was reluctant to do the work. On the contrary, it was necessary to have the men draw lots for the privilege and Byrd reported that they "beg'd they might not be reliev'd, believing they shou'd gain immortal Honour by going thro' the Dismal."<sup>31</sup>

Byrd was not to be denied some opportunity to view the Dismal himself. He and two other commissioners accompanied the survey party for three hours, during which they were able to cover only a half mile. He was thus able to leave us a description of the outer edge of the swamp: "The Reeds which grew about 12 feet high, were so thick, & so interlaced with Bamboe-Briars, that our Pioneers were forced to open a Passage. The Ground, if I may properly call it so, was so Spungy, that the Prints of our Feet instantly fill'd with Water. Amongst the Reeds here & there stood a white Cedar, commonly mistaken for Juniper. Of this Sort was the Soil for about half a Mile together, after which we came to a piece of high land about 100 Yards in Breadth. We were above 2 Hours scuffling thro' the Reeds to this Place . . ."<sup>32</sup>

Further accounts of the swamp were obtained later from the surveyors. On the second day they found the reeds and briars even thicker than the first: "But the greatest Grievance was from large Cypresses, which the Wind had blown down and heap'd upon one another. On the limbs of most of them grew Sharp Snags, pointing every way like so many Pikes, that requir'd Pains and Caution to avoid . . . These trees being Evergreens, and Shooting their Large Tops Very high, are easily overset by every Gust of Wind, because there is no firm Earth to Steady their Roots."<sup>33</sup> The third day of work was largely through "Juniper Swamp with very thick underwoods and fallen Trees." They were able to cover only about a mile and a half each day. After a Sunday of heavy rain had added to their misery, they resumed work on the fifth day and managed a little over two miles.<sup>34</sup>

After five or six days without word from the surveyors the commissioners became very concerned, but probably less so than the survey party who "began to be alarmed with Famine, and not without reason for their Provisions grew very scanty Nor could they discern any marks of being near Land. They had seen neither Bird nor Beast since their Entrance into this barren wilderness, to supply their wants, nor so much as an insect or a reptile." As their rations ran low they were "reduced to such Straights that they began to look upon John Ellis's Dog with a longing Appetite, & John Evans who was fat & well liking, had reasons to fear that he wou'd be the next Morsel."<sup>35</sup> The complete absence of animal life seems remarkable but it must be remembered that insects and reptiles are not expected in early March and that the

<sup>25</sup> *Ibid.* pp. vi-viii.

<sup>26</sup> *Ibid.* p. 25.

<sup>27</sup> *Ibid.* p. 27.

<sup>28</sup> *Ibid.* pp. 42-62.

<sup>29</sup> *Ibid.* p. 60.

<sup>30</sup> *Ibid.* pp. 60-62.

<sup>31</sup> *Ibid.* p. 61.

<sup>32</sup> *Ibid.* p. 65.

<sup>33</sup> *Ibid.* p. 66.

<sup>34</sup> Saunders, ed., *Colonial Records*, 11, 753.

<sup>35</sup> *Ibid.* p. 754; Boyd, ed., *Byrd's Histories*, p. 83.

party doubtless made enough noise to scare away other animals. Finally, on the eighth day surveying was abandoned and they tramped due west all day without leaving the swamp. They covered five or six miles and toward night were able to hear cattle and dogs. On the ninth day they finally emerged. After a weekend of rest they returned to their task and completed it in three more days.<sup>36</sup>

The surveyors reported no very remarkable discoveries in the swamp. They had been fortunate in the time chosen: "By the Description the Surveyors gave of the Dismal, we were convinc'd that nothing but the Exceeding dry Season we had been bless'd with cou'd have made the passing of it practicable. It is the Source of no less than five Several Rivers which discharge themselves Southward into Albemarle Sound, and of two that run northerly into Virginia. From thence it is easy to imagine that the Soil must be thoroughly Soakt with Water, or else there must be plentiful Stores of it under Ground; to supply so many Rivers; especially since there is no Lake, or any considerable Body of that Element to be seen on the Surface."<sup>37</sup>

The dividing line, Byrd thought, crossed the Great Dismal at its widest point, approximately fifteen miles. He estimated its length to be thirty miles and circumference one hundred, sixty-five in Virginia and thirty-five in North Carolina. He noted that the settlers' cattle and hogs could "keep themselves fat all winter" foraging on the edge of the swamp, but that "they pay dear for it by the Agues & other distempers occasion'd by the noxious Vapours the [that] rise perpetually from that vast extent of Mire & Nastiness . . . . However this dirty Dismal is in many parts of it very pleasant to the Eye, tho' disagreeable to the other Sences, because there is an everlasting Verdure which makes every Season look like the Spring." His accounts of his experiences in supervising the survey make fascinating and frequently hilarious reading.<sup>38</sup>

It is unfortunate that Byrd did not accompany the surveyors all of the way through the swamp. His comments on everything which he observed on the outside suggest that he might have provided a clearer description than emerged from the surveyors' accounts. If not clearer, it certainly would have been more colorful. His interest in the Great Dismal continued after the survey was completed. He not only wrote the two histories of the survey but he also recorded a "Proposal" for the formation of a company to drain and exploit the swamp.<sup>39</sup> None of these manuscripts were published in his lifetime.

It is evident that he had given a great deal of thought to his proposal. In general terms he indicated that the swamp was of no value to the Crown as it was. There seemed to be no interest in obtaining land grants there. It only served to maintain unhealthy living conditions for settlers near it. If the Crown would make a grant of the entire swamp to a com-

pany and waive quit-rents for ten years, the company could then afford to buy slaves and drain and clear the area. In the course of drainage canals would have to be dug. These would not only provide to the company transportation for crops such as hemp to be grown on the cleared land but they would also connect the rivers of Virginia with those of North Carolina and thus promote commerce. Virginia would reap "the benefit of being the port and public mart, to which the inhabitants of North Carolina must bring their commodities."

More specifically, Byrd thought that there should be twenty shares in the company but with as few shareholders as possible. He suggested that the Earl of Orkney, Sir Charles Wager, Sir Jacob Acworth and Colonel Bladen be invited to encourage this subscription. Ten negroes should be purchased to build houses, prepare a garden, and clear and trench ground. They should be both male and female. It would be good to have wives for the men to keep them from wandering at night, catching colds and becoming dishonest, and their work suffering next day! If some died, children would be coming along to replace them. In fact, it might be a good idea to lay out some money for children "who will not only season better . . ." but would soon be fit for labor. There should be twenty slaves purchased the second year and twenty-five each year thereafter. He estimated costs for everything, including soliciting the grant in England, surveying the land, purchasing cattle and slaves, erecting a house for an overseer, a barn and slaves' quarters. His final estimate totalled four thousand pounds' outlay during the first eight years and predicted a tenfold increase in value of shares. He considered the land to be as good as any in the country. Slaves could be taught how to "make shingles, burn tar and draw clapboards."<sup>40</sup> He had noted in his *History* that the citizens of Norfolk "have a pretty deal of Lumber from the Borders on the Dismal, who make bold with the King's Land thereabouts, without the least Ceremony. They not only maintain their Stocks upon it, but get Boards, Shingles and other Lumber out of it in great Abundance."<sup>41</sup>

The survey of the line had made clear that the Great Dismal was less hazardous than had been supposed and, as time went on, others began to consider its potentialities. In 1755 the Governor of North Carolina reported to the Lords of Trade: "There are several large Swamps or Bogs called here Dismal Swamps which are low grounds covered with Reeds or Canes interspersed which will be the best Lands in the Province when reclaimed, some of these are from 10 to near 30 miles long and from 10 to 20 miles broad particularly one adjoining Virginia . . ." Carolina citizens had earlier shown interest in such reclamation. In 1740, people living in Pasquotank County petitioned the legislature for an act to force those in Currituck to "clear that part of the great Swamp that leads through the head of Pasquotank into Currituck."<sup>42</sup>

<sup>36</sup> *Ibid.*, pp. 78-80.

<sup>37</sup> *Ibid.*, p. 84.

<sup>38</sup> *Ibid.*, p. 87.

<sup>39</sup> The "Proposal to Drain the Swamp" was published by Edmund Ruffin as part of an article, "Observations Made During an Excursion to the Dismal Swamp," *The Farmers' Register* IV (January, 1837), 513-524. See also Earl G. Swem, ed., *William Byrd of Westover, Description of the Dismal Swamp and a Proposal to Drain the Swamp* (Metuchen, New Jersey, 1922).

<sup>40</sup> Ruffin, "Proposal," *The Farmers' Register* IV (January, 1837), 521-24.

<sup>41</sup> Boyd, ed., *Byrd's Histories*, p. 36. Exactly what Byrd did with the "Proposal," if anything, is not clear.

<sup>42</sup> Saunders, *Colonial Records*, VI, 608; IV, 497.

A few grants were being made in and about the swamp. William Wright, Jr. took out another 130 acres "in the main swamp" in 1735. John Duke and Thomas Mace patented 189 acres the following year. Daniel Rothery patented 1300 acres and built a mill which appears on the earliest map of the swamp. In 1762, Colonel Robert Tucker received a grant for

1,000 acres, and the following year he acquired another 2,000. He built a causeway and road and also a mill. Others receiving grants were John Mercer, William Cowper, Dr. Ferrey and Charles Wilkins.<sup>43</sup>

<sup>43</sup> DSLC-DU: Gershom Nimmo to Fielding Lewis, 20 November 1763, Swem Dismal Swamp Papers, The College of William and Mary, subsequently referred to as Swem DS Papers, W & M.

## II

The first major development which would have great impact on the Great Dismal occurred in 1763. It was almost certainly inspired by William Byrd's proposal for draining the swamp. Byrd was no longer living but his son, William Byrd III, was well acquainted with some if not all, of the principal persons involved.

On May 15, 1763, four men set out on a horseback tour around the Great Dismal.<sup>1</sup> All of them had a keen interest in land. They were the thirty-one year old George Washington (whose wife was the niece of William Dandridge, a fellow commissioner of Colonel Byrd in 1728), his brothers-in-law Burwell Bassett and Fielding Lewis, and Dr. Thomas Walker, whose wife was Mildred Thornton, a Washington cousin. Walker had been one of the most enthusiastic supporters of the Loyal Company which was interested in lands along the Ohio River. He was an active explorer himself, later founding the westernmost settlement in Virginia by building a cabin in what is now Kentucky. On this trip, there was to be no real attempt to penetrate the swamp deeply but rather to circumnavigate the area in which the men were interested. In this manner, they would be able to keep to the roads which ran on the edges of the swamp, both coming and going.<sup>2</sup>

From Suffolk they rode south on the road to the west of the Dismal. This led to the edge of the Pocason Swamp, six miles distant. Two miles from Suffolk the road crossed the creek which supplied power to Colonel Riddick's mill. They were impressed by Willis and Henry Riddick's plantations, both being level and high enough to have firm ground. Two and a half miles south of Pocason lay the Cypress Swamp which was reputed to drain more water into the Dismal than any other although it was quite dry at the moment. This condition being favorable for exploration on horseback, they decided to penetrate the main swamp as far as possible. The horses did not sink over their fetlocks and, with little difficulty, they were able to proceed well over a half mile, the first part of which was covered with towering pines and "Galberry" bushes. Pines and hollies gave way to reeds as the soil changed from sand, becoming black and seemingly rich.

The land along the road continued damp and poor until they reached John Riddick's plantation close by Mossy Swamp. Two miles further on they came to that of "one Brindle," who lived just north of the

Carolina line. When they came to the "Main Swamp of Oropeck," they found the Widow Norfleet's mill and the plantation of Luke Sumner. They were really impressed to see the Norfleet and Sumner meadow. It was between two and three thousand acres and located on the swamp mouth which had enriched it incalculably. Lewis and Washington noted its possibilities and later bought 1093¼ acres from Marmaduke Norfleet for £1300.<sup>3</sup> The road passed several other swamps and nowhere was it more than two or three miles from the Great Dismal. Washington observed that all the way to the bridge over the Perquiman River the land was "dead level—wet and cold in some places, sandy and generally poor."

Their way now lay east, as they did not continue on the road to the River Bridge, and on to the Paspotank River at Ralph's Ferry. Instead, they chose to go more directly, visiting a small settlement between the Perquiman and the Dismal. There, they took the new road north which had just been cut through the main swamp. After five miles they arrived at what Washington said the inhabitants called "new found land, which is thick settled, very rich Land, and about 6 Miles from the aforesaid River Bridge of Paspotank. The Arm of the Dismal which we passed through to get to this New Land . . . is ¾ Miles measured little or no timber in it, but very full of Reeds and excessive rich. Thro this we carried horses without any great difficulty. This Land was formerly esteemed part of the Dismal, but being higher, tho' full of Reeds, People ventured to settle upon it and as it became more open, it became more dry and is now a prodigious fine land, but subject to wets and unhealthiness."<sup>4</sup> Already the vast swamp had commenced the inevitable erosion by draining, which has resulted in its yearly decrease in size.

As the travellers went north on the swamp's eastern boundary, they came to the conclusion that there was little fall but that it was lower on the eastern and southern sides. They passed by an arm of the Dismal seven miles north which they were told ran fifteen to twenty miles to the east, with an outlet into Currituck Inlet through the Northwest River. Those who gave this information seemed so uncertain that the travellers gave little credence to their statements although they were certain that the swamp did drain to the east. Thus Washington thought a causeway built in an easterly direction would soon drain the area dry. Three miles north of the Virginia line they came to

<sup>1</sup> "The Adventurers for Draining the Dismal Swamp," Swem DS Papers, W & M.

<sup>2</sup> This account of their trip is taken from John C. Fitzpatrick, ed., *The Diaries of George Washington* 4 vols. (Boston & New York, 1925), I, 188-194. It was under the date of 15 October 1763, but actually referred to their travels between May 25 and 28 of the same year.

<sup>3</sup> 26 April 1766. It was sold to John Cowper in 1791 for £1090, but there was no indication whether this was paid for Washington's half or for the whole tract: Archibald Henderson, "George Washington was a Carolina Land Owner," *The Uplift*, XXXI (17 September 1943), 12-13.

<sup>4</sup> Fitzpatrick, ed., *Diaries*, I, 192.



the Northwest River where they found flat boats and other small craft loading at a landing. From there on to Great Bridge, crossing the southern branch of the Elizabeth River, they rode through beautiful farm land valued as high as three pounds per acre. From Great Bridge they turned somewhat west and, after an eight mile ride, came to Colonel Tucker's mill. Finally, on May 28, they arrived back in Suffolk.

This great tour had not been taken casually. On the day they had set out, they and others had filed a petition with the Governor and Council seeking grants of Great Dismal land. Action on their petition was postponed until the November meeting. The Executive Journal of the Council did record the submission of the petition on May 25 for grants of land in the "Great Dismal" which had "lain entirely waste and unpatented hitherto."<sup>5</sup> The petition which was submitted in November read as follows:

The petition of William Nelson Esqr. & many others humbly shews that they being desirous of taking up and Improving a large Tract of waste Land lying in the Counties of Norfolk and Nansemond bounded to the southward on Carolina and commonly known by the name of Dismal Swamp did present a Petition to the Honble. Governor and Council which was read the Twenty fifth of May last and the consideration thereof postponed. AND WHEREAS by some means the said Petition has been mislaid and Cannot be found by which your Petitioners are deprived of the advantage of having the same reconsidered. They therefore Pray that leave may be granted them to Survey and obtain Patents for the said Lands on the terms which they then petitioned for as will appear by the Council Journals—or on such other Conditions as your Honours shall think reasonable—and yor Petitioners as in duty bound shall &c.

The Council considered the petition and granted permission for each petitioner to "take out a Patent for one Thousand Acres," providing that notice was given to those whose land bordered on the said patent, and that it did not interfere with previous entries. Seven years were allowed for surveying and patenting.<sup>6</sup>

This was no small grant to several men but a very large grant indeed. The potential amount was 154,000 acres, for there were 153 signers of that petition in addition to William Nelson—not eleven as has been rather generally suggested. The prime promoters were George Washington, Fielding Lewis and Dr. Thomas Walker. It was they who obtained the additional signatures and the assignment of their rights to themselves and nine others. Washington was responsible for 46 names, Walker for 40 and Lewis for 68. It is not surprising to find that the larger list contained the names of many of their relatives. There were, for example, seven Washingtons and nine Lewises among those easily identified.<sup>7</sup>

Two days after the Council had given its blessings

to their petition, twelve of the petitioners (or in some cases their proxies) met at Williamsburg to form a "Company of Adventurers" for the purpose of draining the Great Dismal and reclaiming the land there.<sup>8</sup> Whether the additional petitioners had been offered an opportunity to join the company and declined, or had merely permitted the use of their names, is not known. There does not appear to be any record of their having been paid for the assignment of their interest to the "Adventurers." The only expense recorded in this connection was an item of seven shillings recorded by Washington. There evidently was an agreement among most of the twelve to furnish fifteen names in addition to their own, which most of them did.<sup>9</sup> Washington carefully preserved the assignments, at least for a time, in case their title should be questioned.<sup>10</sup>

The twelve Adventurers were men of substance and, in many cases, connected by marriage. In addition to Lewis, Walker and Washington, there were Thomas Nelson, Secretary of His Majesty's Council, and his brother William, also a member of the Council; Colonel Robert Tucker of Norfolk, Thomas Nelson's stepson; Robert Burwell, the Nelsons' cousin; John Robinson, Speaker of the House of Burgesses; William Waters of Williamsburg; John Syme, half brother of Patrick Henry, whose wife was Dr. Walker's step-daughter; Samuel Gist, a Virginia merchant in London who had settled in Hanover County; and Anthony Bacon & Company. Bacon was a prosperous merchant of London, who had spent a few years in the colonies earlier. He was to be elected to Parliament in the following year. He was in partnership with Gilbert Franklyn, a West Indian, as Anthony Bacon & Company. The company interest in the Great Dismal would be represented by Fielding Lewis.<sup>11</sup>

Articles of agreement for the formation of the Adventurers were drawn up and voted upon. It was decided that agents chosen by the company would inspect the land and determine the most efficient method of draining it. They would estimate the cost and levy an assessment to cover expenses. If a member failed to pay the required sum he would forfeit his land to the company. The total land could only be divided by a majority vote of the shareholders. A member who wished to sell his share must give the company the chance to purchase it. If a fraction of a share was sold, only one person could vote the share.

Having completed these formalities, discussion centered on the mechanics of starting the company. It was decided that some members should approach the surveyors of the two counties involved and inspect their books in order to ascertain what entries had already been made. Washington, Walker and Lewis volunteered for this task and were accordingly appointed managers. Since no draining or preparation of the land could proceed without a labor source, it was decided that each member would furnish five

<sup>5</sup> Benjamin J. Hillman, ed., *Executive Journals of the Council of Colonial Virginia*, VI, June 20, 1754–May 3, 1775 (Richmond, 1966), 257–58.

<sup>6</sup> *Ibid.*, 257–58 and 687.

<sup>7</sup> Copy of petition, including the 154 signers in Swem DS Papers, W & M. Unfortunately, no attribution is given.

<sup>8</sup> Minutes of meeting, 3 November 1763, Swem DS Papers, W & M.

<sup>9</sup> See list at Morristown (New Jersey) National Historical Park.

<sup>10</sup> David Jameson to Dr. Thomas Walker, 31 October 1783, DSL–DU.

<sup>11</sup> L. B. Namier, "Anthony Bacon, M. P., an Eighteenth Century Merchant," *Journal of Economic and Business History*, II (November, 1929), 24–25, 31–32.

slaves by the coming July. In the meantime, the managers should locate a plantation adjoining the Dismal on high ground. They would furnish it with tools, provisions and clothes for the people. An assessment of fifty pounds per share was made and Washington duly recorded his payment for that and the cost of the surveyors.<sup>12</sup> Colonel Lewis employed Gershom Nimmo, who had been appointed surveyor of Norfolk County in 1753, to undertake a search of titles of land-owners in the Great Dismal. On November 20, Nimmo presented him with a list of those patents entered in the swamp but not surveyed or only partially. Of the 5800 acres which he listed, 5172 had not been surveyed.<sup>13</sup>

When the Virginia Assembly met in January, they passed a bill approving the company's drainage project. It was introduced by Richard Henry Lee and the Act stipulated that the company had permission to cross others' lands, make canals and roads through adjoining land without being liable to suit. However, there was provision for arbitration for those who felt that they had suffered injury.<sup>14</sup> By April, changes in share-ownership were taking place. Colonel Syme resigned his to a Colonel Farley and one half of Waters' share went to his son-in-law, David Meade of Nansemond.<sup>15</sup>

In the early summer of 1764 Washington again visited the swamp, this time in order to start the work. It was his third trip for he had been there in October, 1763 when he spent the night with his brother John who had a home in the Dismal.<sup>16</sup> On this trip, Washington went alone and his expense account was only seven pounds, fourteen shillings, one pence.<sup>17</sup> Not only did he start the work of clearing and draining but he studied the land itself and its possibilities far more thoroughly. This appears to have been the trip he described in a letter to Dr. Hugh Williamson some twenty years later:

I traversed Drummonds pond through its whole circuit; for the purpose of forming a plan for reclaiming the Lands, more than with a view to the benefit of navigation and at a time when it was brim full of water. I lay one night on the east border of it, on ground something above the common level of the Swamp; in the morning I had the curiosity to ramble as far into the Swamp as I could get with convenience, to the distance perhaps of five hundred yards; and found that the water at the margin of the Lake (after it had exceeded its natural bounds) was stagnant, began perceivably to move Eastward; and at the extent of my walk it had deepen'd, got more into a channel, and increased obviously in its motion. This discovery left no doubt in my mind, that the current was descending into one of the rivers of Albemarle Sound . . . My researches, at different times, into, and round this Swamp (for I have encompassed the

whole) have enabled me to make the following observations. That the principal rivulets which run into the great dismal, if not all of them, are to the westward of it, from Suffolk southwardly. That Drummond Pond is the receptacle for all the water which can force its way thro' the reeds, roots, trash and fallen timber (with which the Swamp abounds) into it. That to these obstructions, and the almost perfect level of the Swamp, are to be ascribed the wetness of it. That in wet seasons, when the banks of the pond are overborne by the assemblage of the waters from the quarter I have mentioned, it discharges itself with equal difficulty, into the heads of the rivers Albemarle, Elizabeth and Nansemond; for it is a fact, that the late Colo. Tucker of Norfolk, on a branch of Elizabeth River, and several others on Nansemond River, have Mills which are, or have been worked by the waters which run out of the Swamp.<sup>18</sup>

It was necessary for some land to be bought in addition to that patented. The three managers purchased almost 200 acres of the original William Wright patent, some from Stephen Wright and some from James Wright.<sup>19</sup> Members of the company met again in December when it was resolved that each member would pay forty pounds in addition to furnishing four male and one female slave.<sup>20</sup> Washington recorded an appraisal of the slaves as given by each member on July 4, 1764. They totalled forty-seven and were valued at £2775. Sometime later he added another eight (value £595). Of the fifty-five, eleven were women and two were children. Speaker Robinson's slaves did not meet the standard set and he was assessed £52.<sup>21</sup>

Land had been leased from Mills (Willis?) Riddick on which the company erected buildings to house the workers. There was already a settlement called Dismal Town and a causeway running east to Lake Drummond as both are shown on the map prepared by the surveyor Nimmo (Figure 1). The map is entitled "Washington's Real Estate Adventure in Great Dismal Swamp Lands" and is dated November 20, 1763.<sup>22</sup> A little later a canal was dug to the lake, following the old causeway, so that flat boats could be used to transport shingles and timber. The exact date of its construction is unknown but it was sometime before 1772.<sup>23</sup> It was probably quite narrow to start with but was widened as time went on. For generations it has been known as the "Washington Ditch," whether George or John is unspecified. In June another £300 was assessed and a similar amount the following year. The company was at last in production and cypress shingles were being sold. From Washington's ledger it also appears that John Washington was acting as agent for the company in 1765 since it is under his name that 70,000 company shingles are credited. He may well have been in

<sup>12</sup> 31 May 1784, John C. Fitzpatrick, ed., *The Writings of George Washington*, 39 vols. (Washington, 1931-1944), XXVII, 378-79.

<sup>13</sup> 7 December 1764 and 11 February 1765, *DSLS-DU*.

<sup>14</sup> "Memorandum D.S. Company," 15 December 1764, *DSLS-DU*.

<sup>15</sup> "Appraisal of Slaves sent to the Dismal Swamp, July the 4th 1764," Henry E. Huntington Library and Art Gallery.

<sup>16</sup> Photostats in the Library of Congress.

<sup>17</sup> Advertisement of sale of the late Josiah Riddick's 75 acres adjoining "the great ditch in the Dismal Swamp," *Virginia Gazette*; 19 November 1772.

<sup>18</sup> Swem DS Papers, W & M.

<sup>19</sup> *Ibid.*

<sup>20</sup> William Waller Hening, ed., *The Statutes at Large: Being a Collection of all the Laws of Virginia From the First Session of the Legislature in the Year 1619*, 13 vols. (Richmond and Philadelphia, 1809-1823), VIII, 18-19.

<sup>21</sup> 27 April 1764, list of original proprietors in Box 1, *DSLS-DU*.

<sup>22</sup> Fitzpatrick, ed., *Diaries*, I, 296.

<sup>23</sup> Washington's account for "The Adventurers for Draining the Dismal Swamp," Swem DS Papers, W & M.

charge of the work force from the very beginning since his home at this time was in the swamp.

When Mills Riddick died his executors were willing to sell the leased land to "The Company of Adventurers." In December 1766, the first payment of one hundred pounds was made to them, of which Washington paid seventeen pounds, seven shillings, ten pence.<sup>24</sup> Nimmo was employed to make a survey of the company holdings including the just purchased land. The accompanying description said the survey began at the mouth of Pocason Swamp running south to "the southernmost House at Dismal Town." Reference was made to the "pond Landing" and details of the Riddick land given. The company holdings totalled 10,449 acres, not including the lake and ran all the way to the Carolina line.<sup>25</sup>

Washington made two trips to the swamp in 1767.<sup>26</sup> One of them may have been to look over 238 acres of swamp in Nansemond County which he and the two other managers patented on September 10.<sup>27</sup> It was not until May 1768 that the company's articles of agreement were formally acknowledged before the General Court and recorded.<sup>28</sup> Two deaths among the original shareholders occurred not long afterwards: Colonel Tucker in 1768 and Speaker Robinson in 1769. The latter's share was bought in by the company leaving twelve full shares for the remaining eleven members.<sup>29</sup>

Other people were taking out patents in the Dismal. Three men, Edward Wright and two others, patented four hundred acres "known by the name of the wild Cow Ridge." Two weeks later four others patented four hundred acres adjoining "Edward Wright and Company."<sup>30</sup> This precipitated action by William Nelson and the other members who "entered all the Vacant Land and Swamp adjoining the same in Norfolk County," on August 7, 1770.<sup>31</sup>

The company accounts kept by George Washington end in 1768, at which time his brother John succeeded to the formal title of Manager, although he had been doing the actual overseeing for several years, possibly since 1764. This is borne out by an advertisement in the *Virginia Gazette* in 1771:

Run away from the Subscriber, in Isle of Wight, a Negro named JACK, about five and thirty years of Age, five Feet ten Inches high, a slim, clean made, talkative, artful and very saucy Fellow. Also a Negro Woman named Venus, thirty two Years old, five Feet four Inches high, stout made, very smooth tongued, and has been five Years accustomed to the House. They worked in the Dismal Swamp about two Years, under Mr. John Washington,

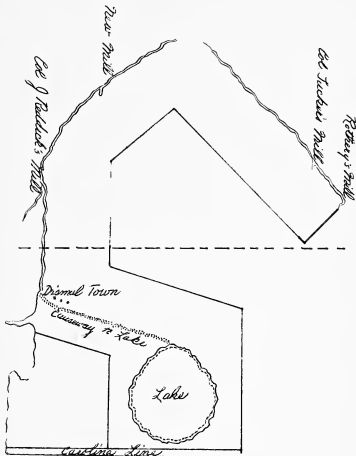


FIG. 1—Adapted from the earliest known map of Lake Drummond from a survey of lands in the Virginia part of Dismal Swamp. Prepared by Washington's Surveyor, Gershom Nimmo, and dated Norfolk, 20 November 1763.

and carried with them several different kinds of Apparel. Whoever delivers the said Negroes to me, or secures them so I may get them, shall have a Reward of FORTY SHILLINGS for each  
NATHANIEL BURWELL

These two slaves had been part of Nathaniel's father's share furnished the Land Company around 1764. They were on Washington's 1764 list, Venus being valued at sixty pounds and Jack at seventy.

The demand for shingles continued. John Washington advertised in the same paper on May 13, 1773: "I am desired to give notice to those Gentlemen who are indebted to the Dismal Swamp Company for shingles, that if they do not discharge their accounts by the 25th of July next they will be put into the hands of an attorney, without further application." In March, 1774, Robert Carter ordered 25,000 cypress shingles to be delivered at David Meade's saw mill from which they would be shipped to him.<sup>32</sup> An ingenious utilization of the swamp lands was instituted when the company began the raising of rice. By 1777, John Washington shipped fifty-five casks of it to Antigua.<sup>33</sup>

<sup>24</sup> Washington's account for "The Adventurers . . .", Swem DS Papers, W & M.

<sup>25</sup> Nimmo's survey for "Col. Washington & Company" recorded on the back of a complaint for non-payment by Henry Riddick, Swem DS Papers—W & M.

<sup>26</sup> Washington's account for "The Adventurers . . .", Swem DS Papers, W & M.

<sup>27</sup> Washington, Walker and Lewis patented Dismal Swamp land adjoining that of George Walker and David Meade, Ed: Wright and Joseph Jones, DSLC-DU.

<sup>28</sup> Copy in the Virginia Historical Society, File 5-28-1.

<sup>29</sup> Washington's account for "The Adventurers . . .", Swem DS Papers, W & M.

<sup>30</sup> 7 August 1769, DSLC-DU.

<sup>31</sup> 7 August 1770, *ibid*.

<sup>32</sup> Robert Carter Papers, Letterbook 1, 184-86, Duke University.

<sup>33</sup> 17 May, order to pay Wm. Aylett £210.01.02 for 55 casks of rice to John Taylor, Antigua, DSLC-DU.

## III

Rumors of impending war reached the Great Dismal area in the late spring of 1775. The day after the battle of Lexington, the Virginia governor, Lord Dunmore, ordered his men to seize the powder magazine at Williamsburg, and declared Patrick Henry a traitor. So infuriated were the Virginians that, in June, Dunmore fled to the safety of the British warship, the *Royal William* and sailed down to the navy yard at Gosport, near Norfolk. By August, he had organized the local Loyalists into a fighting force and raised an regiment of Negroes soon known as his "Ethiopians." To this indignity accorded the planters, always under a threat of a slave uprising, was added an even more serious one when, in November, Dunmore offered freedom to both indentured servants and slaves who joined his forces. He defeated the Princess Anne militia in October and proceeded to fortify Norfolk where he declared martial law.<sup>1</sup>

A British traveller, J. F. D. Smythe, who had spent some time in America, wrote an interesting account of wartime conditions there. He had escaped from the rebel forces which had captured him and had paid a Negro two dollars to hide him in the swamp:

This *Great Dismal* is the principal of all those dreadful places called Swamps, only to be met with in America . . . It is in form of a vast oval, thirty miles in breadth, and fifty in length, with a lake nearly in the center, seven miles in diameter, abounding with fish.

Throughout the whole of this truly *dismal* place, there is scarcely the least appearance of any kind of soil; for even where there is no water nothing can be discovered but cypress knees, closely intermixed with a matted body of strong fibrous roots vines and vegetative productions everywhere, in a dark and dreary shade altogether, impervious to the rays of the sun. The trees, &c. growing so close thick and lofty, that one person will lose another therein, at ten yards distance; and afterwards if they wander a few hundred yards asunder, no noise, clamour, or hallowing, from either of them, can be heard by the other, for the woods are so close as to prevent the vibration of air for any distance through them; even the report of fire-arms is smothered.<sup>2</sup>

Smythe reported that bears, wolves, panthers, wild cats, possums, coons, beaver and some deer were to be found on the ridges. He mentioned an abundance of muskrats, otters and snakes. Seeing evidence of fires, he learned that, in droughts, the ridges were often accidentally set afire. The hollows left where the accumulated fallen trees burned on the ground, became small ponds. There was still talk of one immense fire which had burned for weeks and caused the animals to flee to the plantations on the swamp's fringes. Smythe wrote "This place is also called the *Great Desert*" since there were no "human in-

habitants," thus making it secure not only for animals but for runaway slaves.<sup>3</sup>

Smythe was interested in the Land Company operations: "This swamp belongs to a company of proprietors, who have begun to render it of advantage and profit to them. They commenced with getting lumber, cypress shingles, and boards, and with considerable labour, they have now formed several plantations therein, which produce immense crops of Indian corn. They have also cut a navigable canal, nine miles in length, from the great lake, for the conveyance of lumber and produce . . . and they have formed a causeway of timber, as a road through it, from the end of the canal."<sup>4</sup>

On the northern fringes of the Dismal, there was a 120 foot long bridge across the southeastern branch of the Elizabeth River. There, the two roads coming from Carolina to the east and the west of the Dismal, met. Here, the produce was unloaded from the carts and put on board ships for Norfolk and points north. The town on the southern side was known as Great Bridge. Dunmore quickly realized the bridge's importance as a land approach to Norfolk. He gave orders to build a fort there. It was completed November 6 and manned by a small force of twenty-five men, with a lieutenant, a sergeant and a corporal.<sup>5</sup>

The Virginia Committee of Safety gave Colonel William Woodford orders to march to the Norfolk area with his Second Virginia Regiment. He was able to repulse a British attack on Hampton and then went to the defense of Great Bridge. There he was joined by 350 Minutemen from Culpepper, Fauquier and Orange counties. Among the Fauquier contingent, arrayed in hunting shirts, were Major Tom Marshall and his son, Lieutenant John, later the Chief Justice. Woodford had an earthen breastwork thrown up on the southern side of the causeway. Sporadic fighting began December 4, when sixteen Negroes and five whites were killed. The following day, an American boat guard stationed five miles away, was attacked but successfully relieved. On December 7, Woodford's forces totalled over a thousand men, having been reinforced by three of Colonel Patrick Henry's companies and a North Carolina militia company. The colonials were anxious to trap the British into a pitched battle and Major Marshall baited the trap. He sent his servant with orders to reveal that there were only three hundred Americans but that they would be reinforced by several hundred shortly. The ruse worked and the British attacked on the ninth, with only one hundred and twenty regular troops and a mixed bag of sailors, marines and Negroes. The battle of Great Bridge, one of the first of the Revolution, lasted only a half hour. Over one hundred British were killed or wounded and only one "rebel" was wounded.

Norfolk changed hands twice again before Dunmore left for England in July, 1776. Among the many who had suffered from his actions was the "Company of Adventurers." They credited him with enticing

<sup>1</sup> Elizabeth B. Wingo, *Battle of Great Bridge* (Norfolk County Historical Society of Chesapeake, Virginia, 1964), pp. 11-14.

<sup>2</sup> J. F. D. Smythe, *A Tour in the United States of America* (Dublin, 1784), II, 147-48.

<sup>3</sup> *Ibid.*, 149.

<sup>4</sup> *Ibid.*, 150.

<sup>5</sup> Most of this account is from Wingo, *Battle of Great Bridge*, pp. 15-31.

away six of their slaves: three forty-year-olds: David, "black and lusty," Will, bearing the scars of small pox and Harry, "Short and thick;" two thirty-five-year olds, York and Norfolk, and a thirty-year-old "Boy Harry, Spare and slim."<sup>6</sup> Although Dunmore had departed, much lawlessness in Princess Anne and Norfolk was credited unjustly to the Loyalists in 1777. These illegal activities became such a threat that Governor Patrick Henry offered \$150. for the arrest of the leaders, the principal one being Josiah Philips.<sup>7</sup> He would retire to the Dismal with fifty or more men and, as Jefferson said, "from thence sallied forth, plundering and maltreating the neighboring inhabitants, and covering himself, without authority, under the name of a British subject."<sup>8</sup> In May, 1778, Henry raised his reward to \$500. and unsuccessfully sent one hundred militia after the bandits. They were followed by state troops. Henry and Jefferson decided a bill of attainder was the only solution. Philips was finally caught, indicted for robbery in spite of his claim of being a British subject, and hung December 4, 1778.<sup>9</sup>

Throughout the war years, the Land Company managed to survive, with Colonel Henry Riddick succeeding John Washington as manager, and Jacob C. Collie overseeing the work. Starting in 1778, David Jameson, the treasurer, had invested company funds each week in Virginia Treasury certificates to a total of £12,408.16.0. Taxes were paid yearly and some of the expenses were offset by the sale of corn, fodder, rice and lambs.<sup>10</sup> The war moved close to the swamp again in late 1780 when the British retired from the north side of the James River to Portsmouth. General Leslie commanded a post between Nansemond River and the Dismal. Militia from Princess Anne and Norfolk Counties, including many from the Dismal area, continually made attacks on the British.<sup>11</sup>

In 1775, the Land Company had had fifty Negroes "most of them Fellows and at least forty good working hands with Tools of every kind necessary for the plantations about 30 head of Cattle, very few if any sheep & the stock of Hogs not worth mentioning."<sup>12</sup> Now, at war's end, Collie reported to Jameson on the state of the company property which had suffered from the British. Twelve more slaves had been lost to Goodrich and Cornwallis.<sup>13</sup> Collie's letter of July 31, 1781, gave more details:

Sir,

This will inform you the Damage done to the Dismal Swamp by the British on their Late Excursion down this quarter, to Portsmouth—They have

taken all the old Corn, say upwards of 2000 Bils, all the Stock, saving 10 or 12 Head, all the Slaves, saving five that fit for any kind of Labour, all the Tools, that is all the Hoes, Axes, &c—besides a great many new files, sorted as well as great damage done to several of the out Houses, Particularly Barnes, as well as some of my Nigh Neighbours that is endeavouring to make reprisals of a Negro Fellow & Two Cart Horses, the former of which were with the Enemy, but the latter were also. James Batts is the person, who I can prove, Harbours the Slave Tom. The Horses were taken from me by the Enemy, But were not Carried away, with them, but taken up by Henry Lassiters Son of Aaron, and now in Possession of Jason Riddick, who absolutely refuses giving them up Saying they are Legal prizes—Owing their being, once in the hands of the Enemy—in answer to this matter, Please so advise me, as soon as Convenient. The Country has had abot. 300 Bils Corn, besides Blades & Rice, The Vouchers for which, I have never been able to get the whole signed by the Commanding Officers, but will do it if possible, after wch shall send them to you if you require it for to enable you to get Payment. There seems a very promising Crop Corn & a Little Rice, but how its to be got in, I know not, as well as how matters are to be conducted in future, for want of help. please to write fully.

He added that his personnel loss was also great, having had all of his corn stock and eight Negroes seized. The end of the war left the company with but eleven men of whom seven were "pretty good," six women and three children.<sup>14</sup>

On May 4, 1779, the Virginia legislature passed an act declaring void "all orders of council or entries for land in the council books" unless actually surveyed as directed. There was one exception: "a certain order of council for a tract of sunken grounds, commonly called the Dismal Swamp. . ."<sup>15</sup> The implication was that the Land Company was allowed their claim although the surveys were not complete. With the war over, others were taking out large grants. In July, 1782, John Cowper used his Treasury Warrant to patent 1410 acres known as Pumpkin Line Plat, adjoining Company land. There was also an entry of Wells Cooper & Company for 6,000 acres.<sup>16</sup> Available swamp land was gradually disappearing. Even more worrisome, David Jameson wrote to Dr. Walker on June 22, 1783, was that he was told several persons had taken out warrants "intending to locate them" on the company's lands and "the opinion prevails that they will hold them as we have not proved to survey." Robert Andrews, who had been employed to make a survey of 40,000 acres, had been slow in completing it. However, the company had conscientiously paid taxes on them each year. Jameson requested Walker to ask Jefferson's advice as to their legal status.<sup>17</sup> In reply, Walker wrote that

<sup>6</sup> Jacob C. Collie's "List of Negroes that went to the British," April 1781, DSLC-DU.

<sup>7</sup> William Wirt Henry, *Patrick Henry, Life, Correspondence and Speeches*, 4 vols. (New York, 1891), I, 611.

<sup>8</sup> Jefferson to William Wirt, 14 August 1814, Albert Ellery Bergh, ed., *The Writings of Thomas Jefferson* (Washington, 1907), XIII, 170.

<sup>9</sup> Henry, *Thomas*, I, 613. His case became a *cause célèbre* later.

<sup>10</sup> "Memorandum of Money lent Virga. Treasury in the Name of Dismal Swamp Company," 7 July 1780, and David Jameson to William Nelson, 25 October 1784 as well as Jameson's Account 1773-1785 and that of Collie 1782-DSLC-DU.

<sup>11</sup> Jefferson to Samuel Harrington, 3 November 1780 and Jefferson to Steuben, 17 February 1781, Julian P. Boyd, *The Papers of Thomas Jefferson* (Princeton, 1950—), IV, 92, 643.

<sup>12</sup> John Driver to Jameson, 15 January 1790, DSLC-DU.

<sup>13</sup> Collie's "List of Negroes that went to the British," DSLC-DU.

<sup>14</sup> J. C. Collie to David Jameson, DSLC-DU.

<sup>15</sup> Henning, *Statutes* X, Ch. XII, 38.

<sup>16</sup> 1795 survey of 29 July 1782 and Memorandum February 1783, DSLC-DU.

<sup>17</sup> DSLC-DU.

"Our having paid the taxes is a proof that no fraud was intended" but he would consult Jefferson.<sup>18</sup>

Andrews completed the survey in October but Jameson felt that it would be controversial since other Land Office warrants on the land had been issued to various people. He called for a company meeting November 5, in Richmond.<sup>19</sup> He was startled to learn that the original grant had been made for over 150,000 acres and wrote Walker that "I never knew how many persons were on the list that the grant was made to. I believe you, Gen. Washington & Mr. Lewis managed that business & got the proper assignments—I suppose they will be called for if our title is disputed."<sup>20</sup> At the meeting, Robert Andrews' survey of 40,000 acres and his bill for £100 were presented. Few came and Jameson discovered that the members were offended that he, who had no authority, had called it. They did not consider it official. In April, 1784, Jameson replied to David Meade's letter in which he had stated that he thought the company was on the verge of bankruptcy. Jameson denied it and wrote: "I am far from Considering the Compa. in a State of Bankruptcy as you seem to do. They have funds enough, but we have been taught by our Country that Funds and money are two different things. The money I recd. belonging to the Co. in the Age of Paper I placed in the Loan Office as I recd. it, and have in my possession certificates in the amo. of £12,000."<sup>21</sup> That summer he urged Walker to ask "the great & good Gen. Washington" to name a time and place of meeting which should persuade all the members to attend.<sup>22</sup>

Walker had proposed a meeting to Washington months before this and the general had replied in April that he thoroughly approved. He suggested that Walker issue a notice of it and that it should be held in Richmond. He added that it had been nine years since he had heard any news of the company and that he would very much like a copy of Andrews' survey.<sup>23</sup> He wrote to Walker again in late August, having had no answer to his previous letter nor yet seen an announcement of the company's meeting in the paper.<sup>24</sup> A meeting for October 16 was finally called. A few days later, Walker paid the £25 Register's fee for issuing the company's 40,000 acre grant.<sup>25</sup> If Washington attended the November meeting, he made no note of it. He did send an ad of a meeting to be held in Richmond the following May and recorded that a quorum of the Proprietors met in the Senate Chamber there.<sup>26</sup> They acted upon Jameson's suggestion that five to six thousand pounds be borrowed to drain lands and to purchase Negroes. William Anderson was given authority to borrow the smaller sum at 5% or less for not less than seven years.<sup>27</sup> For labor,

Washington conceived the idea of using European workers rather than buying Negroes. He wrote to John de Neufville in Amsterdam on September 8, inquiring about importing Dutch or German workers, knowledgeable in draining and other agricultural operations. He was disgusted to find that de Neufville was already on his way to Boston.<sup>28</sup> He talked to a Dutch merchant in Alexandria just before he left for New England and asked him to inquire about the possibilities among his colleagues whom he would be visiting along the way. Unfortunately, nothing came of that matter.<sup>29</sup> Meanwhile, Jameson had advised Collie to hire ten Negroes for that year.<sup>30</sup>

John Driver reported in August 1786 that there were insufficient Negroes "to keep the place in order, the Ditches are much broke & require a deal of Work on them, the present Crop is almost drowned, there will be little Corn made." He wished that some of the company's members would visit to review the situation.<sup>31</sup> In January 1787, Jameson wrote to Driver, apologizing that nothing had been done and "to manage as well as you can." By spring, they hoped to procure the white servants since there was not sufficient money to buy Negroes and no one was willing to hire out their slaves.<sup>32</sup>

For the next ten years, the company correspondence, mainly between Jameson and Driver, was continuously gloomy. Although sales of shingles numbered in the millions and many pales were sold, there was never sufficient money for the taxes or supplies. Norfolk County as well as Nansemond attempted to collect taxes. There were bad debts. Collie left and it became increasingly impossible to find a good overseer. Encroachments on company land continued to be a source of worry. Sexton and John Cowper, partners in a lumber business, continually cut large quantities of timber off company land. Driver suggested, rather sadly, that if they would only pay for its value, it might be a good idea. Strangers from the "Northd." made entries on company land near Deep Creek. At least there was one happy note: Patrick Henry and George Kelly compromised respecting their swamp lands interfering with those belonging to the company.<sup>33</sup> The shares continued to change hands through death and sale. One of Driver's letters was carried by a Mr. Bacon in 1791. Anthony Bacon had died around 1785. He left his interest in the company, 2/3 of a share, to his half-brother William, who lived in Maryland before the Revolution. This young man was probably William's son, James, for Driver said that his "Father has an Interest in the Dismal & he is getting what information he can respecting the place."<sup>34</sup> The other third of the share belonged to "Mr. Francklyn," presumably heir to Gilbert Franklyn, one-time partner in Anthony Bacon & Company.

It was all exceedingly discouraging for the Proprietors. Washington replied to John Jameson's

<sup>18</sup> 23 June 1783, DSLC-DU.

<sup>19</sup> David Jameson to Colonel John Page, John Lewis and Colonel T. Newton, 21 October 1783, DSLC-DU.

<sup>20</sup> David Jameson to Dr. Walker, 31 October 1783, DSLC-DU.

<sup>21</sup> Note, April 1784, 1783, DSLC-DU.

<sup>22</sup> 15 July 1784, DSLC-DU.

<sup>23</sup> 10 April 1784, Fitzpatrick, ed. *Writings*, XXVIII, 391-92.

<sup>24</sup> 25 August 1784, *ibid.*, 463.

<sup>25</sup> The grant lay in both Norfolk and Nansemond counties and the Register's receipt was dated 19 October 1784, DSLC-DU.

<sup>26</sup> Washington to Bushrod Washington, 3 April 1785, Fitzpatrick, ed., *Writings*, XXVIII, 120-21; Fitzpatrick, ed., *Diaries*, II, 372.

<sup>27</sup> Rough memorandum of meeting, 2 May 1785, DSLC-DU.

<sup>28</sup> Fitzpatrick, ed. *Writings*, XXVIII, 259.

<sup>29</sup> Washington to John Page, 3 October 1785, *ibid.*, 286-87.

<sup>30</sup> 15 February 1785, DSLC-DU.

<sup>31</sup> Driver to William McCauley, 26 August, DSLC-DU.

<sup>32</sup> 25 January, DSLC-DU.

<sup>33</sup> Thomas Shepherd to Colonel John Jameson, 17 August 1798. This and the preceding information from DSLC-DU.

<sup>34</sup> Driver to Jameson, 19 May. This letter and other information are all in the DSLC-DU.

request for another \$80. assessment for the company, that he had never received a cent's return on his investment in more than twenty years.<sup>35</sup> Nevertheless, he had written glowingly of the value of his share in 1793 when he hoped to sell it to Governor Henry Lee: "This swamp in fertility of soil, cannot be exceeded—It is covered with the finest Cypress & Juniper, & other lofty wood—Its undergrowth is luxuriant Canes—In the opinion of the Subscriber it may be easily drained, & when drained is equal to the richest riceland of So. Carolina, which, in its unreclaimed state, sells from ten to fifteen pounds sterling pr. acre and from thirty to fifty when reduced, and in order for cultivation." Washington praised the situation, close to Norfolk, Portsmouth and Suffolk; its excellent transportation; and the fine plantation. He was asking £5000 for his 2/21 share. In a later memorandum, he refers to the 40,000 acres and the fact that the shareholders "have a just right to a good deal more which has been taken from them (illegally, and not past recovery) through their own inattention."<sup>36</sup>

In 1797, Alexander Macauley, Norfolk merchant who had bought half of Fielding Lewis' share from his executor in 1773, engaged Benjamin Henry Latrobe to survey the company land and to advise upon improvements. The engineer and his two companions, having missed the York stage that day in early June, went to Petersburg and down the river to Smithfield, where they spent the night. Unfortunately Latrobe's journal makes no further comment except that "The excursion into the Dismal Swamp opened a prospect for professional pursuits of more importance to me. I saw there too much to describe at random and too little to describe at all without seeing more."<sup>37</sup> He did present an expense account for \$60. to Thomas Swepson, company Treasurer at that

time, for "a Hammock, Bill hooks,—a Quadrant—boots, Jacket, &c . . ."<sup>38</sup>

Over the years, North Carolinians, as well as Virginians, recognized the Dismal's possibilities but have left fewer records. The Lebanon Company, similar to the Dismal Swamp Land Company, had vast timber interests south of the state line. Its holdings were even larger than those of its Virginia counterpart. It had mills at the upper end of Pasquotank River. Here developed a town known as Old Lebanon, now South Mills.<sup>39</sup> In 1779, an Act was passed giving Gideon Lamb, for twenty-five years, the right to build a bridge "or causeway . . . through the Great Swamp from Lebanon to Camden County—" Although the bridge had been built by 1782, a petition was made to repeal the act but was rejected.<sup>40</sup> In May 1784, Demsey Burgess and others unsuccessfully sought to enter lands in Camden County which would be tax exempt for a time.<sup>41</sup> It may have been because there was still some doubt as to the line dividing the Counties of Camden and Currituck in the Dismal. Sometime during that year it was defined, dividing the swamp equally between the two counties.<sup>42</sup> Virginians patented Carolina land, too. In addition to Washington, Patrick Henry and his son-in-law, John Fontaine, had land in both Camden and Gates Counties.<sup>43</sup> There was little temptation for any casual inspection of land opportunities in Carolina, for the post road was nearly impassable. A postal inspector in 1777 reported that water on it was up to the horses' knees.<sup>44</sup>

<sup>35</sup> Latrobe to Thomas Swepson, 21 June 1797, DSLC-DU.

<sup>36</sup> The Lebanon Company owned between forty and fifty thousand acres. Hugh Williamson to Washington, 24 March, 1784, DSLC-DU.

<sup>37</sup> Saunders, *Records of North Carolina*, XIII, 578; XV, 64; XIX, 272.

<sup>38</sup> *Ibid.*, XIX, 593, 603, 419.

<sup>39</sup> See David Leroy Corbitt, *The Formation of the North Carolina Counties, 1663-1943* (Raleigh, 1950).

<sup>40</sup> John Fontaine to Henry, n.d., Patrick Henry Papers, The College of William and Mary.

<sup>41</sup> Hugh Buckner Johnston, ed., "The Journal of Ebenezer Hazard in North Carolina, 1777 and 1778," *The North Carolina Historical Review*, XXXVI (July, 1959), 360.

<sup>35</sup> 15 February, Fitzpatrick, ed., *Writings*, XXXIV, 112-13.

<sup>36</sup> Memorandum for Governor Henry Lee, *ibid.*, 349-51.

<sup>37</sup> Benjamin Henry Latrobe, *The Journal of Latrobe* (New York, 1905), xv.

#### IV

William Byrd's suggestion that a canal connecting the Nansemond or Elizabeth River with Albemarle Sound would be a profitable development did not bear fruit until after his death. Whether or not he had any influence in bringing it about cannot be determined. There does not seem to be any record of any further promotion of the idea until 1784. On March 24th of that year, Dr. Hugh Williamson, Continental Congressman from North Carolina, wrote to George Washington on the subject:

You are probably informed that there is a company in North Carolina called the Lebanon Company who own 40 or 50 thousand acres of land on the south side of Drummond's Lake or the Great Dismal. I presume their lands are bounded to the northward by the Lands of ye Virginia Company of which you are a member. By the last post I received letters from some gentlemen who are of the Lebanon Company proposing a Plan which they apprehend will not only tend to the improve-

ment of all the lands on Albemarle Sound and greatly promote the commerce of Virginia. They propose to dig a canal from the head of Pasquotank into the lake in the dismal & thence into some navigable water which leads into Chesapeake Bay.

He went on to discuss the proposal at some length, suggesting that the company be incorporated by the legislatures of both Virginia and North Carolina.<sup>1</sup> Washington promptly replied that he had long thought such a canal would be practicable although to dig one large enough to accommodate any vessel capable of navigating Albemarle Sound would be too ambitious.<sup>2</sup> He sent a copy of Williamson's letter to Dr. Thomas Walker. On July 15th of the same year, David Jameson, Treasurer of the Land Company, had received a copy of the letter from Dr. Walker and

<sup>1</sup> DSLC-DU.

<sup>2</sup> Washington to Williamson, 31 March 1784, Fitzpatrick, ed., *Writings*, XXVII, 378.

commented in his reply: "I am fully convinced of the great benefits that would arise both to the public and to individuals could a navigable canal pass through the Lake but there is very little probability that our present Comp. will ever engage in it."<sup>3</sup>

Benjamin and Joseph Jones of Pasquotank have been credited by some with originating the idea of a canal in North Carolina.<sup>4</sup> Enthusiasm for the project was by no means universal there. Williamson sounded discouraged when he wrote on December 11, 1784 to Thomas Jefferson at Paris: "People near Edenton are afraid that a canal from Pasquotank River, through Drummond's Lake, would deprive that town of its small remains of Trade, and the people of Pasquotank River who would be profited by the canal have not Enterprise enough to go on with Work."<sup>5</sup> Jefferson became caught up in enthusiasm for the enterprise. He replied to Williamson on February 6, 1785: "I am glad to find you think of me in the affair of the Dismal. It is the only speculation in my life I have decidedly wished to be engaged in." He had previously written to James Madison concerning the proposed canals at Cayuga and the Great Dismal: "These works will spread the field of our commerce westwardly and southwardly beyond any thing ever yet done by man."<sup>6</sup>

Williamson's pessimism was not entirely justified. Already the wheels were beginning to turn. In 1785 the Virginia General Assembly authorized the appointment of a commission to study the feasibility of a canal. Patrick Henry, whose second term as governor began in November of that year, had an active interest in the improvement of navigable rivers of the state and encouraged the proposal.<sup>7</sup> Robert Andrews and John Cowper were appointed by Henry to meet with a North Carolina group. Henry wrote to Governor Caswell of North Carolina informing him of the Virginia action and requesting that North Carolina cooperate.<sup>8</sup> On March 12, 1786, Caswell replied, agreeing to present the Virginia proposals to his legislature. He had definite reservations about doing so, however, for on the previous day he had written to Abner Nash, sending a copy of the Virginia resolution and commenting that such a canal might be "a means of making our neighbors our Carriers and giving them advantage of exporting our most valuable Produce . . . according to some N. Carolinians." In spite of his reservations, he did present the Virginia proposal to the Assembly on November 20, 1786, and on November 27 a letter from Andrews and Cowper suggesting December 8 for a meeting.<sup>9</sup> Galloway and Macon of the Senate, and McLaine and McKenzie of the House were appointed to meet with Andrews and Cowper at Fayetteville on December 9. Further consideration of the canal was postponed pending their report of the meeting to the next

session of the Assembly. The question of approval of the proposed canal was hotly debated at the next several sessions of the Assembly. Opponents of the measure objected on grounds which were not without merit. Virginia already had very adequate seaports which North Carolina lacked. The canal would profit Virginia and discourage North Carolina from improving its own ports. Norfolk would corner all commerce while North Carolina was "dwindling into fishing towns." It was improper to allow a small group of men such a monopoly on trade. Furthermore, it was politically unwise to enter into an agreement by law which could only be repealed with the consent of another government. In spite of all such arguments the more immediate benefits of being able to ship goods readily must have weighed more heavily with the legislators for the Act passed its third reading in 1790.<sup>10</sup> Arguments against it would have carried more weight had not North Carolina long been sending its produce to Norfolk by other means.

The Virginia General Assembly, not surprisingly, was more easily persuaded of the virtues of such a canal. Virginia could scarcely lose by its construction and had much to gain. The act approving the canal was passed December 1, 1787. It was long and detailed, providing for the condemnation of land, the raising of funds by subscription, and even establishing the toll charges to be made for each of a long list of commodities. It specified the width and depth of the canal to be dug but this was modified by an amendment to the act in 1790.<sup>11</sup> Although the worst obstacle might seem to have been removed when the approval of the North Carolina Assembly was obtained, there remained the impressive problem of raising sufficient funds. The legislators had approved the project on a subscription basis, not as a state financed undertaking.<sup>12</sup> The Virginia General Assembly did authorize in 1791 the state Treasurer to purchase and vote fifty shares of the company, and again in 1799 the addition of twenty more.<sup>13</sup> North Carolina did not commit any state funds. The raising of money by subscription went slowly in both states and no actual digging began until 1793. The company could not be incorporated until at least half of the authorized capital of \$40,000 had been subscribed at \$2.50 per share. George Washington subscribed \$500.<sup>14</sup>

It is doubtful that even the most ardent supporters of the canal proposal had a clear understanding of the magnitude of the undertaking. The written record which survives seems to suggest that they were amazingly vague about such basic questions as the exact route to be followed and the number of locks required.<sup>15</sup> The early proposal made by the Lebanon Company and supported by George Washington, for a route through Lake Drummond must have been

<sup>3</sup> DSLC-DU.

<sup>4</sup> Clifford Reginald Hinshaw, "North Carolina Canals Before 1860," *North Carolina Historical Review*, XXV (January, 1948), 15.

<sup>5</sup> Boyd, ed., *Jefferson*, VII, 569.

<sup>6</sup> *Ibid.*, VII, 642.

<sup>7</sup> Robert Douthat Meade, *Patrick Henry, Practical Revolutionary* (Philadelphia and New York, 1969), p. 269.

<sup>8</sup> Saunders, ed., *Colonial Records*, XVIII, 26, 234.

<sup>9</sup> Brown, *Canal*, p. 33; Saunders, ed., *Colonial Records*, XVIII, 571, 114, 26.

<sup>10</sup> *Ibid.*, XVIII, 56-57, 296; XXI, 1082-83; XXV, 83-93.

<sup>11</sup> Henning, ed., *Statutes*, XII, 478-79; Anonymous, *Dismal Swamp Canal Company Rules & Regulations*, (Norfolk, 1820), pp. 3-16.

<sup>12</sup> Hinshaw, "North Carolina Canals . . .," *North Carolina Historical Review*, XXV (January, 1948), 19.

<sup>13</sup> Henning, ed., *Statutes*, XIII, 264; Anonymous, *Dismal Swamp . . .*, pp. 18-19.

<sup>14</sup> Henning, ed., *Statutes*, XII, 478-79; Hinshaw, "North Carolina Canals . . .," *North Carolina Historical Review*, XXV (January, 1948), 19.

<sup>15</sup> Duke de la Rochefoucault-Liancourt, *Travels Through the United States of North America*, 4 vols. (London, 1799), III, 13.



abandoned rather early. Among the papers of the Dismal Swamp Land Company at Duke University there is a rather rough sketch entitled "The course of the intended canal thro' the Dismal Swamp as surveyed by N. Forster." This shows a route east of Lake Drummond and approximately that actually followed. It shows the canal beginning near Tucker's mill on Deep Creek, running "S. 12 W 10 miles" to a point where it makes an oblique angle and continues "S 21 1/2 E 11 1/2 miles" to a bridge over the Pasquotank River at Joy's (Joyce's) Creek. The angle formed by the two lines would be roughly opposite Lake Drummond.

When the digging began it was started from both ends. Hired slaves were used for some of the work and some was contracted at \$4,000. per mile. Remarkable progress was made considering the tools available.<sup>18</sup> Three years later the Duke de la Rochefoucauld visited the Dismal while on a tour of this country and gave an interesting account of the canal:

They are at present forming a canal which passing through the Dismal Swamp, is to unite the waters of the fourth branch of Elizabeth River, or rather of Deep-Creek which falls into it, with Albemarle Sound, by the River Pasquotank, and which will thus considerably shorten and facilitate the communication between North Carolina and Norfolk. This canal, to which the two legislatures of North Carolina and Virginia have severally given their sanction, is carried on by subscription: it is three years since it was begun; and in three years more it is expected to be finished. It is to be twenty-eight miles in length, and to run through a soil which is said to be very favorable for the purpose, and easily worked. Five miles of it are already dug on the Virginia side, which I examined with some care, and thought very well executed. The Dismal-Swamp has less solidity than any other which I have ever seen: but the earth which is dug for the passage of the canal hardens in the air, and makes an excellent dike.

What must appear surprizing, is that, for this canal which already seems in such a state of forwardness, no levels have been taken. It is not yet known what number of locks may be necessary, and even whether any will be requisite. Consequently it is impossible to ascertain what may be the expense of completing it, or even whether the success of the undertaking can be depended on. It is thus almost all the public works are carried on in America, where there is a total want of men with talents in the arts, and where so many able men, who are perhaps at the moment unemployed in Europe, might to a certainty make their fortunes at the same time that they are rendering essential service to the country.<sup>17</sup>

The visit, in 1803, of another distinguished guest has been widely cited. The Irish poet, Thomas Moore, found inspiration there for his ballad, "The Lake of the Dismal Swamp."<sup>18</sup>

The estimated completion date for the canal which the Duke noted was probably obtained from some official of the Canal Company. Thomas Newton, its president, still thought it could be completed in 1799 in February of that year but he was unduly optimistic.<sup>19</sup> The two waterways were not joined until 1805 and even then four miles of the canal were only at half width. Although the many delays must have been discouraging to canal enthusiasts, the canal was by no means useless during the twelve years of digging. Shallow draft boats were able to make some use of the two ends for various purposes. Newton was able to report to George Washington that the Company was paying subscribers punctually and that the Company was increasing in value.<sup>20</sup>

The Company had to contend with a wide variety of problems in digging the canal and constructing locks. Labor was frequently both scarce and expensive. In 1799 they were threatened with a suit by the Land Company which claimed loss of water from its mills.<sup>21</sup> In 1806 a very bad fire in the Swamp disrupted the work and left trees both in and across the canal.<sup>22</sup> In 1808 high water levels created a variety of problems. Samuel Proctor, who was directing the digging operation at the North Carolina end of the canal, complained bitterly to President Richard Blow: "I makes use of all means to get the water off—I cut loose that lock at Mr. Spences in order to get the water off—But that man known by the name of Isaac Place—goes at the dead hour of the night & stops it—if some measure is not taken to prevent his meddling with that end of the canal it never will be done."<sup>23</sup>

Isaac Pleas gave Blow a different version of the affair:

Having commenced in Lumber getting on this Canal wherein I felt great assurance that I should have all the aid that cou'd be afford from the Canal to get my Lumber to market as the Tool would amount to a respectable sum, in the cours of it, I have discovered at times a secret Ambition In samuel Proctor I suppose it partly originated from the Little Misunderstanding respecting the Canal Tract & the Ben Jones House etc, and the Influence of some persons,—Yet I did not think the spleen would be carri'd so far as to Injure me, until of lately there has appeared some striking features in the conduct of Samuel Proctor that show he would wantonly do me what Injury lays in his power—during those rains he has deprived the New Lebanon Mills of water by cutting away the John Spence Lock under pretense that it wou'd effect the digging at the same time the water has at least 15 Inches Live fall at that Canal Lock.

Pleas continued, at some length, explaining how the water problem could be solved without injury to the

<sup>18</sup> Wm. G. Palmer and others, eds., *Calendar of Virginia State Papers and other Manuscripts Preserved in the Capitol at Richmond* (Richmond, 1875), IX, 6.

<sup>19</sup> James A. Padgett, "Letters of Thomas Newton, Jr.," *William and Mary Quarterly*, 2nd Ser., 16 (January, 1936), 47-48. There seems to be some question whether or not dividends were paid to subscribers at this time.

<sup>20</sup> Thomas Shepherd to William Nelson, 16 October 1799, DSLC-DU.  
<sup>21</sup> Ruffin, "Observations," *The Farmers' Register* IV (January, 1832), 519-20.

<sup>22</sup> 14 May 1808, Blow Papers, The College of William and Mary.

<sup>17</sup> Hinshaw, "North Carolina Canals . . .", *North Carolina Historical Review* (January, 1948), 21.

<sup>18</sup> LaRochefoucauld, *Travels*, III, 13-15.

<sup>19</sup> Stansbury, *The Lake*, p. 1.

New Lebanon Mills and assuring Blow that he had no wish to impede the digging of the canal or to "Injure the young Man nor lessen him in your esteem he seems Quite zealous either to serve the Company or to use the power of the Company to gratify his Private spleen against me."<sup>24</sup>

The original acts of assembly authorizing the construction of the canal had established deadlines for its completion which proved to be far from realistic. Twice it became necessary to request an extension of time. On December 16, 1800, the Virginia General Assembly passed an act extending the completion date for five years from September 19, 1801. This act also directed the Company to construct a causeway on one bank of the canal and authorized the collection of tolls for the use of the partially completed canal.<sup>25</sup> This, too, proved to be insufficient time so again, on January 20, 1807, the Assembly allowed six more years from August 1, 1806, for completion of the work.<sup>26</sup>

Stockholders of the Company became disgusted at times with the slow progress of the work and the lack of dividends on their investment. One wrote a letter to the Company and his fellow stockholders in the columns of the *Norfolk Gazette & Public Ledger* of April 14, 1808, enquiring what had been accomplished in all of this time: "You have marked the course of the canal it is true—you have made an indifferent road, and a boat can swim empty four or five miles in the center of the Dismal Swamp! All this you have performed in little more than sixteen years!" He protested that the stockholders knew little about what went on, and that although at least \$6000 had been received in one year—sufficient for a 7% dividend, no dividend had been declared. In spite of all obstacles the officials of the Company refused to be discouraged and continued doggedly with the undertaking.

The "indifferent road" mentioned by the irate stockholder led to another development. In October 1802, William Farange purchased fifty acres of land in Camden County, North Carolina, several miles south of the Virginia-North Carolina line, and built the first inn of the Great Dismal. This seems to have achieved a somewhat dubious reputation as a "Gretna Green," but being twenty-four miles south of Norfolk and seventeen north of Elizabeth City, it must have provided a much needed rest point for travelers.<sup>27</sup>

As an increasing number of flatboats made use of the canal, it became apparent that there was insufficient water for them during dry periods. Furthermore, if there was to be any question of attracting larger and more sophisticated craft to use the canal something must be done. It was decided to tap the water supply of Lake Drummond as had been authorized by the original act of the General Assembly, by digging a "feeder canal" three miles long two miles north of the dividing line. The Company advertised for bids on the proposal in June 1811, but had no

takers. They reluctantly decided that they must do the work themselves and, in July, advertised for forty or fifty hands.<sup>28</sup> Meanwhile the work at Deep Creek continued. When the lock there was finished in December, the Company announced the completion of the main canal after twenty years of work. The occasion was formally celebrated the following April. Governor of Virginia James Barbour, attended by the president and directors of the Company, watched from a boat the official joining of the waters of Chesapeake Bay with those of Albemarle Sound.<sup>29</sup>

Although the War of 1812 did not directly involve the Dismal Swamp Canal, it did have some bearing on the slow but steady increase of traffic there. A letter from Richard Blow, former president of the Company, to Ebenezer Slade, of Hamilton, North Carolina, in July 1812, gave some dimensions of the canal at that time. Slade had written Blow that he was preparing to build a vessel capable of operating between his home on the Roanoke River and Norfolk, via the canal. He wanted to know the limitations imposed by the canal. Blow replied that the locks at Deep Creek and Joyce's Creek were ninety feet long (eighty-two feet clear) and fifteen feet wide. The five locks between were "the same length & width calculated to pass boats of 3 feet" draft. The canal itself was twenty-two miles long, twenty-two feet wide and six feet deep.<sup>30</sup>

The first vessel large enough to be considered a "ship" passed through the canal in 1814, when a twenty-ton craft loaded with bacon, brandy and other goods made the passage.<sup>31</sup> In spite of the limitations of the canal, sizable quantities of goods passed through it. Major Kearney reported to Congress that "In the year 1815 during the few weeks it was open for navigation tolls were paid on:

6,519,419 shingles
1,160,591 staves
16,703 bushels of Indian corn
2,313 bushels of rice
2,138 hogsheads of tobacco
3,575 barrels of tar
329 casks of turpentine spirits
2,475 bales of cotton
119 barrels of black lead
327 tons of iron
181 tons of lead and powder and shot" <sup>32</sup>

A single Carolina merchant during a six months' period of 1816 shipped: 41,000 pipe staves, 193,000 hogshead staves, 160,000 barrel staves, 370 barrels of tar, six barrels of pitch, 371 barrels of fish, 27 barrels of oil, 2,233 barrels of corn, 10,000 pounds of bacon, 59 casks of flax seed, 2 casks of bees' wax and 16 kegs of lard.<sup>33</sup>

Each year work continued in deepening and improving the canal. In 1816 the stockholders advanced money to improve its width and depth, and to con-

<sup>24</sup> 13 May 1808, *ibid.*

<sup>25</sup> Anonymous, *Dismal Swamp* . . . , pp. 19-20.

<sup>26</sup> *Ibid.*, p. 20.

<sup>27</sup> Jesse F. Pugh and Frank T. Williams, *The Hotel in the Great Dismal Swamp* (Old Trap, N. C., 1964), p. 16.

<sup>28</sup> John C. Emerson, Jr., "The Dismal Swamp Canal," unpublished transcript of newspaper articles, The Mariner's Museum Library, 1950, quoting *Norfolk Gazette & Public Ledger*, 21 June 1811; 10 July 1811.

<sup>29</sup> Palmer and others, eds. *Calendar*, X, 38.

<sup>30</sup> Blow Papers, The College of William and Mary.

<sup>31</sup> Emerson, "Canal," *Norfolk Gazette & Public Ledger*, 11 June 1814.

<sup>32</sup> James Kearney, "Chesapeake and Delaware Canal and Dismal Swamp Canal," *Report to the 14th Congress* (Washington, 1817) pp. 704-08.

<sup>33</sup> Emerson, "Canal," *Norfolk Gazette & Public Ledger*, 1 June 1816.

struct more substantial locks. The latter were built of Juniper wood but were later replaced by stone. The Company was authorized by the General Assembly to raise an additional \$50,000. In 1817, the Assembly invested \$47,000 in the Company. Another lottery was authorized in 1826. The new money enabled the Company to eliminate three locks by raising the banks of the canal.<sup>34</sup>

While the Canal Company concerned itself with the main canal, the Land Company was very much concerned with smaller canals, their means of bringing out shingles and lumber from the inner areas of the swamp. There was apparently quite a network of these. Some of the more important ones can be approximately dated. The first known canal in the swamp was that known as the "Washington Ditch," previously mentioned as having been dug some time prior to 1772. The next canal of any appreciable size completed was the Jericho, providing an outlet from Lake Drummond to the Nansemond River near Suffolk, finished about 1810. The Corapeake canal appears to have been completed in 1822. Another obvious place for a canal was between the headwaters of the Northwest River and the main canal, to provide a connection with Currituck Sound. Permission for its construction was given by the General Assembly in 1818.<sup>35</sup>

Interesting observations on the Great Dismal were recorded in a diary by Samuel Huntington Perkins in October 1817. Perkins, a recent graduate of Yale, was on his way to Hyde County, North Carolina, to serve as a tutor to the children of Dr. Hugh Jones. He went through the Dismal on the road which had been formed when the canal was dug. Logs had been laid as a base and the excavated earth thrown on them. Perkins found the canal traffic fascinating. Going north were lighters carrying lumber and others carried flour and dairy products south from Norfolk. The flatboats were propelled by Negroes walking on the banks. Other slaves were deep in the swamp cutting timber. They had been sent there with overseers and several months supplies. Although there were known to be bears in the swamp, Perkins was much more concerned about runaway slaves. He noted that "Travelling here without pistols is considered very dangerous owing to the great number of runaway negroes. They conceal themselves in the woods & swamps by day and frequently plunder by night . . ."<sup>36</sup>

There had been no direct federal involvement in the canal project prior to 1816 although Albert Gallatin had been interested in it as early as 1808.<sup>37</sup> In 1816, Major Kearney was sent to make a survey of the canal. His report to Congress perhaps stimulated the government to include the canal in its overall plan of "internal communication."<sup>38</sup> Federal interest was amply demonstrated in 1818 by a visit of President

James Monroe. Accompanied by several members of his cabinet, including Secretary of War Calhoun and Secretary of the Navy Crowninshield, Generals Swift and Bernard, Colonel McRee of the Engineer Corps, and others, he travelled through the canal to Elizabeth City and visited Lake Drummond. Rumors that the President had fallen overboard proved unfounded although one or more passengers on another boat did do so when their boat passed over a log.<sup>39</sup>

The federal government became the largest single stockholder of the Dismal Swamp Canal Company in 1826 with the purchase of six hundred of the outstanding 1240 shares. An additional two hundred shares were purchased in 1829.<sup>40</sup> In 1826, Colonel Gratiot, chief engineer at Old Point Comfort, accompanied by three West Point cadets, spent a week making a survey and detailed study of the canal. Among other things determined by their study was the exact elevation (4.7 feet) of Lake Drummond above the surface of the canal. Armed with maps of the area, Gratiot reported his findings to the Secretary of War. He made a number of recommendations for the improvement of both locks and canal. These were gradually carried out in subsequent years to the considerable improvement in the use of the canal.<sup>41</sup>

The canal continued to attract visiting dignitaries. In 1826 Governor John Tyler of Virginia, with a party, was conducted on a tour by the company directors.<sup>42</sup> Three years later President Andrew Jackson was the honored guest. The party set out in carriages for the canal where they boarded a barge sent from the Gosport Navy Yard. Six miles down the canal they landed on the bank where "a collation was immediately spread on the table made of cypress shingles . . . The President . . . and the other gentlemen were each provided with a clean shingle which answered for a plate. The servants handed around the slices of Virginia ham, smoked beef and tongues . . ." Jackson said it reminded him of the days when he had eaten on a log in the forest.<sup>43</sup>

Life was becoming easier for the traveller, whether on business or pleasure. By 1820, a stage coach left Norfolk every Tuesday and Friday morning immediately after the arrival of the Baltimore steam boats. It went by way of the swamp road, reaching Elizabeth City the same day. Steamboats there left for Edenton, Plymouth and Williamston, where stages went to Fayetteville and Raleigh. Return trips were available Wednesday and Sunday evenings.<sup>44</sup> In 1829, a traveller who accompanied a canal company director reported that "Those who have not taken a ride on the banks of the canal for the last three or four years have an enviable treat in store." The writer had been tremendously impressed at the magnitude of the work accomplished in the last few years and was astonished that so few Norfolk people had seen it:

The basin at Deep creek is a beautiful sheet of water half a mile in length and fifteen feet above the level of tide water: the locks constructed of

<sup>34</sup> Anonymous, *Dismal Swamp* . . . pp. 22-29.

<sup>35</sup> Brown, *Canal*, p. 50; Anonymous, *Dismal Swamp* . . . pp. 25-29.

<sup>36</sup> Robert C. McLean, ed., "A Yankee Tutor [Samuel Huntington Perkins] in the Old South," *North Carolina Historical Review* XLVII (January, 1970), 56-85.

<sup>37</sup> Joseph C. Platt, *Examination into Proposal of Improving and Enlarging the Dismal Swamp Canal now owned by the Lake Drummond Canal and Water Company* (New York, 1894), p. 37.

<sup>38</sup> Kearney, *Report*, pp. 704-08.

<sup>39</sup> *Norfolk and Portsmouth Herald*, 10, 12, 15 and 29 June 1818.

<sup>40</sup> Platt, *Dismal Swamp*, p. 42.

<sup>41</sup> Emmerson, "Canal," *Beacon*, 16 November 1826.

<sup>42</sup> John C. Emmerson, Jr., Compiler, *The Steamboat Comes to Norfolk Harbor* (Portsmouth, 1949), p. 11.

<sup>43</sup> *Ibid.*, pp. 114-15.

<sup>44</sup> *Ibid.*, p. 93.

stone in the best style of workmanship. For nearly two miles the left bank is piled up with cypress and juniper shingles, pales, and other lumber, the stores of the contiguous swamp. We were fortunate in passing along the banks when a larger number of vessels than usual were on the canal; it was a cheering sight. Eight of these schooners and sloops of from 30 to 50 tons, belonging to the adjoining district in North Carolina, and were employed in the transportation of lumber to the northern market—formerly by the tedious, hazardous and expensive sea route . . . Three of these vessels were returning from Baltimore and Alexandria; the remainder were bound for those ports, unless they

could find purchasers in Norfolk. Two of the transportation company's boats were at the same time, descending the canal, with produce from Roanoke. The advantage of the canal to the eastern section of North Carolina is immense . . .

We pursued our journey along the canal 11 miles, over a road that McAdam himself could not improve, when we came to the junction of the North West canal, the cutting of which is in active progress . . . There are now 240 hands employed on this.<sup>48</sup>

<sup>48</sup> *Niles Weekly* (reprinted from *Norfolk Herald*), p. 245, 1829.

# V

As the Canal Company was enjoying the fruits of the success of its dream, the Land Company was suffering from internal problems. The entire picture is not clear but it probably began during the early years of the Company's operations with failure to establish sound business practices in the handling of Company funds. Our knowledge of it today comes from the records of a legal action brought by the Company in 1824 against Thomas Griffin of York, not only a member of the Company but its president for two years past.<sup>1</sup> He was not an original member, but probably had acquired by inheritance or purchase a part of the share originally held by Dr. Thomas Walker. Two former members were also involved, John Jameson and Alexander McCauley (McCauley). Jameson had acquired a portion of the share originally held by Samuel Gist and was company manager for a time. Between 1793 and 1797, McCauley, both a member and a director of the Company, had, with the consent of Jameson, also a member and director, "received and applied to his own use at different times large sums of money which with the interest amounted in the month of November 1797 to the sum of \$13,395.69 with interest on the several items from their respective dates . . ." There seemingly was no intention to defraud the Company but unfortunately "McCauley becoming embarrassed he executed to Thomas Griffin & Thomas Nelson of York a trust deed conveying an immense property . . ." This deed was intended to secure the interests of three persons to whom he was indebted: Dr. Corbin Griffin, £2,000; Francis Jordan (Jerdone) £3,000; and John Jameson, £5,000. The property was indeed immense, including land in Warwick County, lots in Norfolk, a half interest in land in Norfolk County, slaves, livestock, crops, furniture, silver and "One ship called the Charles Carter with all her Takle apparel and furniture and One Brig called the Helen together with all her takle apparel and furniture and One Sloop called the John together with her take [sic] apparel and furniture and Ten Shears [sic] in the dismal Swamp Canal Company and one half Share in the dismal Swamp Land Company . . ."

The Land Company was contending in its suit that

it had been McCauley's intention "to secure to the members of the said Company thro' their Director John Jameson the sum of money due to them, and that in fact the £5000 was intended to cover the same & a small debt due to John Jameson individually . . ." Rather ample evidence was presented to show that this was the case. Corbin Griffin and John Jameson had apparently received their money. Francis Jerdone had assigned any debt due him to McCauley's widow, Elizabeth. Only the Land Company had been unpaid. The Company further claimed that "All parties have tacitly acknowledged the claim of the Company thro' Jameson . . . and the Trustee himself a member of the Company not only in the full knowledge of these facts but himself pretending as their president for two years past to promote their interests in this respect under false promises (which will be hereafter stated) induced them to believe until lately that a large portion of the balance due the Company would be paid by him out of funds still held by him as trustee."

Griffin was charged with a variety of sins by the Company including "gross negligence and mismanagement in relation to" his duties as trustee; "failure to use due diligence" in collecting debts due McCauley; allowing "property to waste and decay;" failure to pay money collected to McCauley's creditors; paying himself (as administrator for Corbin's Griffin's estate) "more than he was properly entitled to;" and deceiving the Land Company with regard to \$5,000 paid by France for a ship of McCauley's which had been captured by the French. Griffin had added insult to injury by asking that the Company become his "security to the Government" in order to obtain the money from France to apply to the Company's debt. The Company did so and then "all of a sudden he decided that he is entitled to it himself & forfeited his solemn promise to the Company." To further complicate matters, Robert Anderson, of Williamsburg, administrator of McCauley's estate had convinced McCauley's widow that she was entitled to the money from France and was further contending that all money in Griffin's possession and all debts due McCauley should be paid to Anderson. Unfortunately the outcome of all of this litigation is not known, but it gives some insight into the affairs of the Land Company.

The Land Company could well have used the

<sup>1</sup> Manuscripts in the Francis Jerdone Papers, The College of William and Mary.

money due it from McCauley. They had found their agricultural efforts unprofitable and had leased their "Old Dismal Swamp Plantation" in 1813.<sup>2</sup> In 1818 they had sold twenty-five of the shares they held in the Canal Company in order to raise funds for the purchase of slaves for use in shingle cutting.<sup>3</sup> Hiring slaves for the purpose had become unprofitable. The Company needed something to revitalize it and fortunately it came with the completion of the Canal. The lumber business revived and the Land Company prospered for a time.

When the canal finally became a fully developed and functioning link between the waterways of the two states, a third commercial undertaking arose involving the Great Dismal and played a part in its history. This was the Virginia and North Carolina Transportation Company. This was a stock company organized in 1829. Its first president was George Newton, apparently the same George Newton who was president of the Canal Company. Advertisements seeking freight to North Carolina towns appeared in the Norfolk papers. These bore the name of Robert Soutter, perhaps the business manager of the Company. The digging of the canal had been justified in terms of the contribution it would make to commerce and trade between the states, and the Transportation Company intended to take full advantage of the predicted expansion.<sup>4</sup> Some idea of the potential may be gained from a summary of the canal traffic for the period of May 15 to May 29 of that year:

- 18 lighters with shingles and staves
- 12 rafts of timber and spars
- 5 schooners and 2 sloops from Norfolk to Edenton
- 2 sloops and a schooner for Norfolk
- 8 schooners for Beaufort
- 2 sloops and a schooner for Currituck
- 3 schooners from Weldon and 2 for it.<sup>5</sup>

All of this prospective trade stimulated the shipbuilding business in the area. The Transportation Company promptly placed orders for eight boats designed for use on the canal. These were "schooner rigged" barges. The Company also purchased several others. This was, of course, in the early period of the use of steam engines in vessels and they were just what the Company needed. They were already in use in a limited way in the area. The first one acquired by the Transportation Company was the *Petersburg*. She had been built in New York and was operating between Petersburg and Norfolk. When purchased by the Transportation Company she was sent to Albemarle Sound to serve as a tow boat for the Company's barges. Although rather large for the purpose, she was used for several years there before being replaced by a smaller craft.<sup>6</sup>

As shipping increased on the canal there was in-

creased propensity for the towns at either end. Some of the additional business brought with it predictable problems. More liquor was sold at the taverns and more brawling and carousing followed.<sup>7</sup> Some residents of North Carolina continued to view the whole canal enterprise with a jaundiced eye. A controversy arose over the proposal to remove a bridge below Old Lebanon which would obstruct masted vessels on the canal but the legislature did order its removal.<sup>8</sup> One Carolinian noted that the canal had "barely struggled on for many years . . . utterly unprofitable to the corporation, useless to the public and as sluggish as the dismal pools of its own swamp," but he conceded that it was at last "giving promise of public utility."<sup>9</sup>

The concern of some Carolinians about the canal was not limited to the fact that Virginia reaped greater benefit from increased commerce. They were worried about ecological effects of changes in the drainage patterns in the swamp. The canal was blamed for changes which were occurring in Currituck Sound. The Sound had been connected by a narrow inlet with the sea. It gradually filled with sand bars and finally closed altogether. This, too, had profound ecological effects. The waters of the Sound shifted from salt to fresh, with consequent destruction of oyster beds and salt water fishing. Whether this was triggered by changes related to the canal, or merely came about through changes in the ocean currents is not known, but many Carolinians blamed it on the canal.<sup>10</sup>

The Great Dismal has suffered from periodic fires over the years. The most famous one appears to have been that of 1806. Edmund Ruffin had a firsthand account of the damage from Toby Fisher, a shingler. Thirty to fifty thousand shingles were destroyed. A great many had been thrown in the canal to preserve them but the heat from the top shingles burning dried ones underneath, which rose and were consumed as well. The earth burned to a depth of two feet. Ruffin conjectured that such a fire might have been responsible for Lake Drummond since charred stumps could be found on its bottom.<sup>11</sup> An especially severe fire occurred in 1839. Ruffin had visited the swamp both before and after this fire. On his first trip he described the swamp as he found it in 1836: "The swamp forests, where preserving their original appearance . . . present scenery of solemn grandeur and of rare and peculiar beauty. The forests of Gum and Cypress have not been much damaged by fires, or by the labors or improvements of man—and the trees usually remain of their proper great sizes, and venerable appearance, closely shading the wet, black and level soil. The Junipers do not grow large." Later he added: "Some years after my first visit, in a time of unusual drought, another such devastating fire swept over nearly all the swamp, and destroyed the trees and also the soil for a foot or more in depth . . . The Jericho canal passes for five or six miles through this

<sup>2</sup> Dated October 13. Leasors were Thomas Baines and Benjamin Lässiter, DSLC-DU.

<sup>3</sup> Frederick Hall to James Henderson, 16 January DSLC-DU. \$5500 was realized from the sale.

<sup>4</sup> Brown, *Canal*, pp. 66-68.

<sup>5</sup> Emmerson, "Canal," citing the Norfolk and Portsmouth Herald, 3 June 1829.

<sup>6</sup> Brown, *Canal*, p. 69.

<sup>7</sup> William H. Stewart, *History of Norfolk County, Virginia* (Chicago, 1902), p. 405.

<sup>8</sup> Emmerson, "Canal," citing the *American Beacon* (Norfolk), 10 January 1829 and the *Herald* (Norfolk and Portsmouth) 28 January 1829.

<sup>9</sup> Henry Thomas Shanks, *The Papers of Willie Person Mangum*, 5 vols. (Raleigh, 1956), V, 446.

<sup>10</sup> William S. Forrest, *Historical and Descriptive Sketches of Norfolk and Vicinity* (Philadelphia, 1853), p. 467.

<sup>11</sup> Ruffin, "Observations," *Farmers' Register* IV (January, 1837), 519-20.

scene of former remarkable beauty, and of as remarkable subsequent desolation." He described the burned over area as being covered by "a dense and scarcely penetrable thicket of bushes, shrubs, briars and creeping vines, of different aquatic species, scattered among which are numerous young junipers of but a few feet in height."<sup>12</sup> Fires were not the only hazards to navigation. Winter weather at times became a problem. The winter of 1832 was particularly bad with navigation on the canal interrupted by ice for one thirty-two day stretch, another of twenty-two days and a third of ten days.<sup>13</sup>

It is surprising that Ruffin on his first visit found the swamp not much damaged by man's activities for there had been intensive lumbering operations in it for many years at that time. So much so, in fact, that on June 30, 1836, Colonel Joseph Halladay, manager for the Land Company, reported to Dr. Robert Butler, of Suffolk, the president: "The timber is becoming so scarce, it is impossible to supply the demand." Again, on August thirty-first of the same year, he wrote: "Timber for best quality shingles is exhausted."<sup>14</sup>

Halladay's reports for this period reveal another venture of the Land Company. On May 1, 1839, he wrote: "I am pleased to inform you that the crop of Mulberry Trees is quite promising—the cuttings will average at this time upwards of three feet and the roots more than five. By the process of turning down the sprouts, I shall be enabled to propagate 500 or 1,000 more, which will make the number about 15 or 16,000 trees." They had planted in March 21,500 cuttings and 624 young trees. The Land Company was not contemplating reforestation of the swamp but they had been caught up in a craze then sweeping the country for the raising of silk worms and Mulberry leaves on which to feed them. By June prospects looked less bright. Halladay reported a great failure in Mulberry cuttings in "this section." Some people had lost their entire crop and he did not think that the Land Company would have more than a third of what he had expected. In July he was more cheerful, reporting that nine to ten thousand "*Morus multicaulis*" trees looked promising. By September a new problem had arisen. He wrote: "I find the *Morus multicaulis* speculators are somewhat alarmed—quantities of trees are offered for sale, but very few purchasers—I see in the last Whig a flattering amt of sales being made to some amt in Buckingham for 2 cts per bud—which is much better than could be expected under the circumstances." For several months thereafter he reported no sales or offers for the Mulberry trees and requested instructions, and then the subject was dropped.<sup>15</sup>

Halladay's reports to the President also mentioned another serious problem of the Land Company at this period. On June 1, 1836 he wrote to Dr. Butler that he was troubled by the settlement of a suit in-

volving the Company in favor of their opponent Reynolds. He recommended that they make every effort to avoid suits by compromise when possible, because he feared it had, or might become, a local practice to find against the Company in suits. He noted that "there are so many lines run, and by different surveyors, and so many trees marked, it is impossible to make them believe that any line, however correct, is the right one." This problem of poor public relations had also been brought up by Willis Cowper the previous November when he had written to Dr. Butler recommending Halladay to replace Dr. Shepherd who had resigned as manager. He told Butler that Halladay was the most popular man in the county and that he would be able to counteract the unfortunate and unjustified prejudice against the Company which prevailed in the county.<sup>16</sup>

The Land Company's sales of lumber naturally fluctuated considerably from quarter to quarter and year to year, but on the whole their income was substantial, at least in the 1830's. Halladay's reports of gross income ranged from a low of \$4,521.28 to a high of \$12,123.21 per quarter. Although the Company may have paid no dividends for a number of years, it was now doing very well in this respect. A full share in 1835 received a dividend of \$1480.<sup>17</sup> The stock became increasingly widely held as shareholders died and bequeathed fractions of shares to their heirs. An interesting case in point was the "one thirteenth of a quarter share" acquired by the Society of Shakers, through the will of William S. Byrd.<sup>18</sup>

Although Colonel Gratiot had made suggestions in 1826 for the improvement of navigation through the canal, the federal government appeared to lose interest in the idea for a decade. In 1836 an appropriation of \$15,000 (later increased to \$25,000) was made for the improvement of internal waterways. It was hoped to establish interior steam navigation on a practical basis between Charleston, South Carolina, and the Chesapeake Bay. New surveys were made and it was agreed that improvements were necessary at both ends of the canal. Virginia and the federal government agreed to share the cost of changes at the Deep Creek end. Vessels leaving the canal at this end encountered long delays in entering deep enough water in the Deep Creek end of Elizabeth River. The new canal and lock proposed would put them in deep water of the River within two hours.<sup>19</sup> New locks were to be built at Gilmerton, to be paid for by the federal government, and a new canal would be dug connecting them with the old locks two and a quarter miles away. This would also require the construction of a dam and spillway across Deep Creek near the old locks. All of these changes were undertaken, and they were completed in 1843.<sup>20</sup>

Changes were equally needed at the southern end of the canal. The meandering of Joyce's Creek between the canal and the Pasquotank had well earned

<sup>12</sup> Edmund Ruffin, *Sketches of Lower North Carolina* (Raleigh, 1861), 206-07. A recent fire (1923) burned for three years and covered an area of approximately 150 square miles (Hubert J. Davis, *The Great Dismal Swamp* [Richmond, 1962], p. 39).

<sup>13</sup> Emmerson, "Canal," citing the *Herald* (Norfolk and Portsmouth), 18 May 1832.

<sup>14</sup> DSLC-DU.

<sup>15</sup> 1 July and 1 September 1839, DSLC-DU.

<sup>16</sup> 16 November 1835, DSLC-DU.

<sup>17</sup> Halladay to Butler, 31 August 1836 and Halladay's quarterly report, May 1837, DSLC-DU.

<sup>18</sup> Robert H. Reid, "History of the Dismal Swamp Land Company of Virginia," unpublished M.A. thesis, Duke University, 1948, p. 95.

<sup>19</sup> Brown, *Canal*, p. 87.

<sup>20</sup> William E. Trout, III, "The Gilmerton Lock: A Monument to the Builders of the Dismal Swamp Canal," *An Historical Review*, (Norfolk, 1966), 20-34.

the title of the Moccasin Track. This was the slowest and most difficult part of the entire passage between the Elizabeth River and the Pasquotank.<sup>21</sup> The solution seemed to be a new straight canal from South Mills to the Pasquotank. This was estimated to be three and one half miles, rather than the seven by the existing creek. When actually completed in 1856, Turner's Cut, as it came to be known, was actually four and two tenths miles. The addition of the Gilmerton Cut and Turner's Cut to the canal increased its total length to twenty-nine miles.<sup>22</sup>

With all the travellers and visitors through the Dismal it was inevitable that Major Farange's hospitality would prove inadequate. On Christmas Day, 1829, Isaiah Rogerson announced the opening of his "House of Entertainment."<sup>23</sup> It was situated halfway between Norfolk and Elizabeth City. Although named the Lake Drummond Hotel, it was known as the Halfway House within months. "Large and commodious," it was 128 feet long, with eight private rooms, each with a fireplace. Rogerson claimed that his table was well supplied by nearby markets,<sup>24</sup> although travellers sometimes described the fare as simple hominy and bacon.<sup>25</sup> This may explain the modest prices: 50¢ for dinner, \$1 for board and lodging, with a monthly rate of \$18.<sup>26</sup> The lake water served as a principal attraction. A pale red in color, it was purported to be very healthy and was even advertised as a specialty by the Hygeia House in Portsmouth.<sup>27</sup> For many years it had been used on sailing vessels because of its tendency to stay fresh.<sup>28</sup> The horses of Rogerson's patrons were well provided for, with a carriage house, "good provender" and "careful ostlers." The hotel even promised boats for those wishing to visit Lake Drummond. This proved popular and invalids spent the summer at the hotel in order to take advantage of the medicinal qualities of the lake water.

There was another interesting feature of the hotel. It had been built on the boundary line, thus was half in Virginia and half in North Carolina. Because of the stringency of Virginia marriage laws, this was a great drawing card for her citizens "affording a convenient resort for matrimonial excursions to those whose impatience is too great for them to journey on to our old friend Major Farange's, (the original Gretna Green of Lower Virginia) about four miles farther."<sup>29</sup> The hotel was equally popular as a spot for duels since one could easily step over the state line.<sup>30</sup>

A Norfolk artist, Thomas Williamson, visited the Hotel Drummond and made a sketch of it, showing the canal on which rode the stern-wheeler, *Lady of*

*the Lake*, a sloop and "a transportation boat." The drawing was lithographed by a Boston firm and sold by A. C. Hall of Norfolk.<sup>31</sup> The prints proved popular and were even reproduced on paper money from 1838 to 1861. These were notes in small denominations issued by various banks in Alabama, Delaware, Indiana, New Jersey, New York and Virginia.<sup>32</sup> When the original owner died within months of the hotel's opening, Daniel Rogerson rented it. He announced that "The Bar will be furnished with the choicest wines and liquors of every description and the table supplied with all the delicacies the Norfolk market affords. Pleasure parties of every description will be freely accommodated." He hastened to add that he would "spare no pains to make the establishment equal in respectability and comfort to any other of the kind in the United States . . ."<sup>33</sup> This innkeeper disappeared and the hotel was sold to Amalek Williams around 1831. His brother-in-law took it over in 1834. It was still in business in 1859 when Edward C. Bruce travelled from Richmond to Norfolk and down the new canal to Elizabeth City in the *Calypso*. On his return by the daily coach he visited the hotel and was amused that "The landlord lives and votes in the Tar State. His guests are entertained in the Old Dominion. The place is a famous matrimonial rendezvous."<sup>34</sup>

With the barges and steamboats on the canal there was now an easily accessible highway to the northern markets. Not only did the Land Company flourish but many other lumber companies as well as private individuals. Throughout the swamp, usually on small feeder canals, were the camps of the shingle cutters. In 1836, Edmund Ruffin described them vividly:

Their houses or shanties, are barely wide enough for five or six men to be in, closely packed side by side—their heads to the back wall and their feet stretched to the open front, close by a fire kept through the night. The roof is sloping, to shed the rain, and where highest, not above four feet from the floor. Of the shavings made in smoothing the shingles, the thinnest make a bed for the laborers, and the balance form the only dry and solid foundation for their house, and their homestead or working yard. Yet they live plentifully, and are pleased with their employment—and the main objection to it with their masters (they being generally slaves) and the community, is that the laborers have too much leisure time, and of course spend it improperly. Their heavy labors for the week are generally finished in five, and often in four days—and then the remainder of the week is spent out of the swamp, and given to idleness, and by many to drunkenness. All the work is done by tasks; and the employers have nothing to do except to pay for the labor executed. About 500 men are thus employed in the whole swamp, by the Land Company, and by numerous individual land owners. With all their

<sup>21</sup> See bitter letter to the editor of the *Herald* (Norfolk and Portsmouth) 14 May 1845, quoted in Emerson, "Canal."

<sup>22</sup> Brown, *Canal*, p. 91.

<sup>23</sup> *Herald* (Norfolk and Portsmouth) 25 December 1829, cited in John C. Emerson, Jr., Comp., *Steam Navigation in Virginia and Northeastern North Carolina Waters 1826-1836* (Portsmouth, 1949).

<sup>24</sup> *American Beacon*, 4 January 1830.

<sup>25</sup> "The Dismal Swamp," *Chambers's Edinburgh Journal*, 14 December 1850.

<sup>26</sup> William H. Gaines, "Men Against the Swamp," *Virginia Cavalcade* 4 (Winter, 1854), 27.

<sup>27</sup> *American Beacon*, 13 May 1823.

<sup>28</sup> Davis, *Swamp*, p. 16.

<sup>29</sup> *Herald*, (Norfolk and Portsmouth), 22 November 1830.

<sup>30</sup> Pugh and Williams, *Hotel*, pp. 28-29.

<sup>31</sup> *Herald* (Norfolk and Portsmouth), 30 April 1830.

<sup>32</sup> John A. Musculus, "The Dismal Swamp Canal and Lake Drummond: History on Paper Money, 1838-1865," *The Virginia Numismatist* (June, 1967), 8-9.

<sup>33</sup> *The Elizabeth-City Star and North Carolina Intelligencer*, 18 September 1830.

<sup>34</sup> "Lougings in the Footprints of the Pioneers," *Harper's New Monthly Magazine*, 18 (May, 1859), 724-25.

exposure, the laborers are remarkably healthy, and almost entirely free from the autumnal fevers that so severely scourge all the surrounding country.<sup>35</sup>

After many long years of effort, the Dismal Swamp Canal was at last in very good shape for handling shipping, and was doing a very good business. Unfortunately, its success carried with it the basis for its undoing. Having demonstrated convincingly that canals in the area could be sound and profitable undertakings, even under very difficult circumstances, its promoters inspired competition. Rumors began to circulate of a proposed new and shorter canal. They ceased to be mere rumor with an actual survey of the proposed route by Claudius Crozet in 1840. Work was not commenced at this time and, in 1850, a second survey was made by G. P. Worcester. Finally, in 1856, there was action and in three years' time the work was complete. The route was an obvious one, as a study of a map will show. It simply connects the Elizabeth River with Currituck Sound by the most direct route practicable. This required an eight and a half mile canal from Great Bridge to N. Landing River and dredging of the river. Only one lock was needed—at Great Bridge—and this primarily to protect the canal from injury by tides. The objectives of the Albemarle and Chesapeake Canal were different from those of the Dismal Swamp Canal. It was intended solely to cater to through traffic between Virginia and Carolina waters, and could avoid the problems of the swamp entirely. It was meant to accommodate fairly large craft and the lock at Great Bridge was designed to do so. It was twice as long as any on the old canal and was the largest in North America at the time.<sup>36</sup>

The history of the various locks in the Dismal Swamp Canal has been well dealt with by others, and can only be touched on here. Prior to the construction of the Gilmerton Cut and Turner's Cut, the canal had five elevated levels. A vessel going south was raised at Deep Creek, raised again at Wilkins Lock (3 miles), at Northwest Locks (7 miles) and finally at Culpepper Locks (8.5 miles). The first step down was at Spences Lock (2.5 miles) and the second and last at South Mills Lock (1 mile). When the new cuts were made, the first elevation was at Gilmerton Lock. Wilkins Lock and Spences Lock were eliminated, so the canal now operated with four elevated levels. The new Albemarle and Chesapeake Canal had only one level.<sup>37</sup> It was very much shorter and easier to traverse than was the Great Dismal Canal, and clearly it would take over most of the through traffic from the older canal.

A competitor of a different sort had been in the offing for some time, i.e., the railroads. Their first invasion of the Great Dismal began with the Portsmouth and Roanoke Railroad, incorporated in Virginia on March 8, 1832 and in North Carolina in 1833,<sup>38</sup> with a stock of \$500,000.<sup>39</sup> It was to run from

Portsmouth, Virginia to Weldon, North Carolina, a distance of seventy-nine miles. It would have connections with the steamboats from Norfolk to Baltimore.<sup>40</sup> While the grade was almost level for the whole distance, there were problems. For lack of stone, the whole superstructure would be made of wood, which had to be renewed every six years.<sup>41</sup> The greatest challenge was laying five miles of track through the Dismal and many declared that it was an impossibility. The engineer who surveyed this part may well have thought so for he told Henry Howe that he "found it so formidable a labor as almost to despair of success. In running the line, his feet were pierced by the sharp stumps of cut reeds; he was continually liable to sink ankle or knee deep into a soft muddy ooze; the yellow flies and mosquitoes swarmed in myriads; and the swamp was inhabited by venomous serpents and beasts of prey."<sup>42</sup>

In spite of such discouragement the contractor, Benjamin B. Reynolds, advertised for two hundred laborers in April, 1833. They would be paid \$10 a month in addition to their board. Slave owners would furnish spade or shovel or be responsible for any given the men.<sup>43</sup> As many as 300 men, 30 carts and 40 horses were used at one point.<sup>44</sup> In November, a ship arrived in Hampton Roads, bringing three hundred tons of iron from Liverpool. Over one half of the stock had been sold locally and when the legislature authorized the purchase of the remaining two-fifths by the state in January, there were great celebrations in Norfolk.<sup>45</sup> The tracks were laid on "longitudinal wooden stringers covered with 2½ inch by one-half inch strap iron, "with a gauge of 4'8½." "<sup>46</sup> When the last of the iron was laid in July, 1834, the first train travelled from Portsmouth to Suffolk, ignominiously drawn by horses. The locomotive, *John Barnet*, was one of the first to be built in this country and the road was finally completed to Weldon on December 1, 1836. Freight was carried for eight cents a ton, a high price when compared to today's toll of one and a third cents over the same road.<sup>47</sup>

It was of this railroad which Sir Charles Lyell, noted British geologist, wrote: "The railway itself, when traversing the Great Dismal, is literally higher than when on land some miles distant on either side." The track was, as he said, raised six to seven feet above the swamp on pilings.<sup>48</sup> Its construction had indeed been very difficult. In 1843, the North Carolina portion was sold because of financial trouble due to competition, and three years later the Virginia part was sold at auction and became the Seaboard and

<sup>35</sup> John B. Mordecai, *A Brief History of the Richmond, Fredericksburg & Potomac Railroad* (Richmond, 1941), p. 7.

<sup>36</sup> Turner, "Early Railroad Movement . . ." *Virginia Magazine of History and Biography*, 55 (October, 1947), 363.

<sup>37</sup> Henry Howe, *Historical Collections of Virginia* (Charleston, S. C., 1856), p. 402.

<sup>38</sup> John W. Smith, "Building a Railroad 1832-1952," *The Newcomen Society in North America* (New York, 1952), 9.

<sup>39</sup> Turner, "Early Railroad Movement . . ." *Virginia Magazine of History and Biography*, 55 (October, 1947), 363.

<sup>40</sup> Smith, "Building a Railroad . . ." *The Newcomen Society in North America* (New York, 1952), 10-12.

<sup>41</sup> Chart No. 1, p. 3 of Corporate history of the Seaboard Coast Line Railroad Company.

<sup>42</sup> Smith, "Building a Railroad . . ." *The Newcomen Society in North America* (New York, 1952), 11-12.

<sup>43</sup> Sir Charles Lyell, *Travels in North America in the Years 1841-2*, 2 vols. (New York, 1845), 1, 14-15.

<sup>35</sup> Ruffin, Observations," *Farmers Register*, IV (January, 1837), 518.

<sup>36</sup> Brown, Canal, p. 94.

<sup>37</sup> *Ibid.*, pp. 57-59.

<sup>38</sup> Charles Conrad Wright, "The Development of Railroad Transportation in Virginia," Doctoral dissertation, University of Virginia, 1930, p. 23.

<sup>39</sup> Charles W. Turner, "The Early Railroad Movement in Virginia," *Virginia Magazine of History and Biography*, 55 (October, 1947), 363.



Roanoke Railroad Company. It operated under this name until September 15, 1911, when the company was sold to the Seaboard Air Line Railway.<sup>49</sup> On July 1, 1967, the Seaboard merged with the Atlantic Coast Line to form the Seaboard Coastline Railroad Company.

The difficulty of construction through the swamp encountered by the Portsmouth Railroad did not discourage still another venture a few years later.<sup>50</sup> The day of the railroad had arrived and there were a variety of developments. In 1836, the General Assembly had authorized the incorporation of the City Point Railroad Company to construct a road from City Point, at the junction of the James and Appomattox Rivers, to Petersburg ten miles away. There was already in existence the Petersburg Railroad providing transport into North Carolina at Blakely, and the Richmond, Fredericksburg and Potomac running north from Richmond. The James River was navigable up to City Point. The James River Canal from Richmond to Lynchburg was under construction and, in 1831, the Assembly had authorized the incorporation of the Lynchburg & New River Railroad Company to open up transportation to the Kanawha and the Ohio Rivers leading west. It seemed obvious that a great transport network was underway. Unfortunately, financing the railroad construction presented problems. In 1839, the Assembly authorized the incorporation of the Virginia and Tennessee Railroad Company to build a road to the Tennessee line. This did not get started until 1850 and was not in use all the way to Bristol until 1856. While it was being built the Southside Railroad came into existence, connecting Petersburg with Lynchburg, in 1854.

Petersburg was rapidly becoming a railroad center of some importance by the 1850's, but one obviously desirable connection was still lacking. This was a road from Petersburg to Norfolk with the finest natural harbor on the east coast. In 1851, the Norfolk and Petersburg Railroad was chartered to fill the gap. The Board of Directors were exceptionally fortunate in their choice of a construction engineer to direct the undertaking. William Mahone, then twenty-seven, was a Virginia Military Institute graduate with some years of experience. Not only did he build the road efficiently but, within six years, he became its president and subsequently built it into the great Norfolk and Western Railway. To carry out the first part of this program he had to construct some ten miles of track across the Great Dismal. He did not follow the example of the Portsmouth and Roanoke Railroad and elevate the track on pilings. Instead, he cut trees in a hundred foot wide strip, throwing them to the center and thus built an old fashioned corduroy road on which to pile earth to form the roadbed. He doubtless had opportunity to observe that this method had been very successful for wagon roads in the swamp since the submerged logs never rotted. He

could scarcely have foreseen how long his roadbed would hold up. It is today the roadbed of the Norfolk and Western across the swamp and, according to its president, Robert H. Smith, "requires astonishingly little maintenance."

The advent of the railroads tempted more visitors to the Great Dismal. Following Lyell came a man whose articles aroused much interest among prospective travellers. He was Frederick Law Olmstead. In 1853-1854 he wrote a series of articles for the *New York Times*, describing his travels through the southern states. He was fascinated by the swamp and found that there were even more lumber cutters than Ruffin had found in 1836. J. Seguin alone had one hundred hands and Olmstead reported that during a recent storm he had more than \$20,000 worth of shingles "afloat between the outlet of the swamps and New-York." Swamp land varied in price from twelve and a half cents to ten dollars an acre, depending upon the wood on it.<sup>51</sup> Olmstead's picture of the shingle cutters' life was more detailed than that of Ruffin. Most of the laborers were slaves hired at one hundred dollars a year from their masters. There were one or two winter months which were too wet for work. These the men spent at their own slave quarters where they were allowed to pick up any odd jobs they could and keep the money. Around the beginning of February, the gangs went to the courthouse where they were examined, registered and given passes good for a year. Clothing and food were issued, to be charged against each individual. The gangs, each with an overseer, went deep into the swamp. There a camp was made, usually where shingles had been cut as it offered the driest spot. Except for the overseer's daily shingle count, little attention was paid to the men for the next five months. Each was responsible for his own work. A few were in charge of the mules used to transport the shingles to the schooners in the canals. Olmstead added, "The slave is not in the meantime driven at all; no force is used to make him 'work smart.' He lives as a free man; having the liberty of the swamp; hunts 'coons, fishes, cats, drinks, smokes, sleeps, and works according to his own will.'"<sup>52</sup>

The only requirement was that his work was sufficient to refund the six months' payment to his master as well as the money expended for supplies. Olmstead said this would amount to about \$7.25 for clothing and \$24.75 for food. Cutting 10,000 shingles the man would be credited with \$100. His expenses thus totalling \$81, he would receive \$19 for himself. This, added to the money which he could make from animal skins would allow him to buy a dog, or his wife a dress or other such luxuries. Some even saved their money to buy their freedom. Olmstead learned of one slave, so valued by his master that he served as cook on his schooner to New York. With his saving he was able to buy his freedom for \$500 and sailed to a new life in Liberia. However, the majority was seldom so provident and the slave was far more apt to go on a colossal binge. After vacation, the laborers again returned to the swamp. If their work was satisfactory, they would be hired year after year, remain-

<sup>49</sup> Communication to authors, 2 August 1973, from Donald T. Martin, Assistant Vice President, Seaboard Coast Line Railroad Company.

<sup>50</sup> Information in this and the next paragraph is from Robert H. Smith, "General William Mahone, Frederick J. Kimball and Others—A Short History of the Norfolk and Western Railway (Roanoke, 1949). (Speech before the Newcomen Society of England). It was sent to the authors by Peyton B. Winfree, Jr., Director, Public Relations and Advertising, Norfolk and Western Railway Company.

<sup>51</sup> "The South—Number Twelve," 20 April 1853, p. 2.

<sup>52</sup> *Ibid.* Number Thirteen, 23 April 1853, p. 2.



FIG. 2—"The Barge," by Porte Crayon, from *Harper's New Monthly Magazine*, September 1856.

ing there most of their lives. "Those who have been once broken in, enjoy the life, and would be very sorry to have to give it up and go on to a plantation. They almost invariably have excellent health, as do also the white men engaged in the business." This was attributed by most to the water.<sup>53</sup>

With such a great number of slaves working in the swamp for almost a century, many came to know it better than their masters or other white men. To some it appealed as a perfect refuge from slavery and many of them fled to freedom among the Dismal's terrors. Merle R. Eppse said that "The Dismal Swamp Colony of Negroes continued from generation to generation, defying and outwitting the slave owners right in the midst of the strongest slave-holding communities in the South."<sup>54</sup> Around 1843, a regular business of hunting runaways with guns and dogs developed. Blood-hounds, fox-hounds or bull-

<sup>53</sup> *Ibid*.

<sup>54</sup> *The Negro, Too, in American History* (New York, 1939), p. 159.



FIG. 3—"Carting Shingles," by Porte Crayon, from *Harper's New Monthly Magazine*, September 1856.



FIG. 4—"Horse Camp," by Porte Crayon, from *Harper's New Monthly Magazine*, September 1856.

dogs were used indiscriminately. The men thus engaged were known as drivers and appear to have been quite ruthless, sometimes shooting the slaves when they refused to stop. The runaways managed a bare subsistence, the prey of all. Some were employed by small white landholders, at wages far below the shingle cutters' going rate and they sometimes betrayed them to the drivers. Others were employed by the slave shingle-cutters themselves, who often astonished their bosses by the huge number of shingles which they turned in. The cutters fed and clothed the runaways and sometimes paid them around two dollars a month. If the runaways owed them money they, too, had little compunction about turning them over to the drivers.<sup>55</sup>

While Olmstead was in the Dismal, he visited one of the first men to farm in the swamp itself after the Land Company's unsuccessful attempts at agricultural projects. George Wallace had been very interested in the canal and, in 1841, he began developing land which had been in the family for many years.<sup>56</sup> It was near the Northwest Canal locks and not far from the feeder canal to the lake, now known as Wallacetown. The three-story frame house which he built was noted for its stairs and woodwork and its guest book recorded many a well-known visitor.<sup>57</sup> Olmstead was much impressed by Wallace's accomplishment. He had ditched and drained some of the swamp. On this, he produced excellent crops of corn and potatoes. The latter he found particularly profitable, harvesting 2100 barrels from forty acres and realizing \$8400 from them at Norfolk. The middlemen resold them in New York for from ten to twenty thousand dollars. Such land was available at from one to five dollars an acre, but the cost of reclamation Wallace estimated at fifty dollars an acre.<sup>58</sup>

<sup>55</sup> Olmstead, "The South, Number Thirteen," 23 April 1853, p. 2.

<sup>56</sup> William Wallace patented 2386 acres adjacent to Wallace's and Mercer Grymes's old "Patent Land" on July 26, 1787, DSLC-DU.

<sup>57</sup> Margaret Davis, "Great Dismal Pictures," *The South Atlantic Quarterly*, XXXIII (April, 1934), 174.

<sup>58</sup> "The South—Number Thirteen," 23 April 1853, p. 2. Another swamp resource, in addition to lumber and agriculture, was reported by Dr. Caleb Winslow, who grew up on the edge of the Dismal. He described the activities of a company for developing peat beds, which were anywhere from six to sixty feet thick. They dug out blocks the size of bricks which were then dried. "The Dismal Swamp," essay read before the Baltimore Friends' Meeting, p. 167—(University of North Carolina).

The Dismal and its inhabitants were portrayed for posterity during this period by another visitor, David Hunter Strother, better known as "Porte Crayon." He entered the swamp at Suffolk in March, 1856, provided with provisions, blankets and a "a buffalo robe for bedding." The Canal Company's covered barge supplied transportation (Fig. 2). Crewed by two Negroes, they "each took hold of a long pole, and by the help of a peg and a withe rigged it horizontally, one to the bow and the other to the stern of the boat, so that the ends projected over the tow-path." By pushing these, the boat was thus propelled. The glassy-surfaced canal, the great silence and trees festooned with moss, impressed the artist, as he recalled Moore's poem. He landed on the shores of Lake Drummond where Jim Pierce greeted him with a dinner of ham and eggs. The next day Crayon returned to the main canal where he observed the lighters loaded with shingles and sand (Fig. 3). He visited

"Horse Camp," the shingle-cutters' headquarters (Fig. 4). It was a small collection of "picturesque sheds," where provisions of bacon, molasses, sweet potatoes and whiskey, etc., were stored. He was determined to interview one of the runaway slaves, although warned of the danger. He plodded a couple of miles back into the swamp but when he spotted a huge Negro wrapped in a blanket and armed with a gun, he hastily retreated only too relieved that the man had not seen him. Later, he sketched the Negro and his boatmen identified him as "Osman," of whom they were abjectly terrified.<sup>59</sup> It was Osman whom Harriet Beecher Stowe supposedly used as a model for the hero of her novel *Dred: A Tale of the Great Dismal Swamp*.<sup>60</sup>

<sup>59</sup> David Hunter Strother, "The Dismal Swamp, Illustrated by Porte Crayon," *Harper's New Monthly Magazine* (September, 1856), 441-44, 453.

<sup>60</sup> Davis, *The Great Dismal*, p. 61.

## VI

In 1856, the Dismal Swamp Rangers were organized at Deep Creek and were attached to the 3rd Virginia Volunteers Regiment.<sup>1</sup> A brooding atmosphere of tension prevailed between the North and the South. In April 1861, with the attack upon Fort Sumter, the conflict began. The Norfolk area, with Fortress Monroe and the Gosport Navy Yard, already had Federal troops present. Among their early depredations in the Great Dismal area, was the destruction of the free public school at Deep Creek. It had been proudly built in 1845 as one of the first in Virginia.<sup>2</sup> Berry Benson, a Connecticut soldier in the area, visited the Dismal for distraction on Christmas Day, finding it "silent and lifeless." He walked along the railroad and finally rowed a boat to Drummond which appeared "calm and clear, and not a tree broke the evenness of its surface." Out in the middle a small Negro lad was fishing and on the shore lay many upturned boats. In writing to his parents that night, he reported, "Here, too, all was silent. I would have thought there were denizens of this Swamp and Lake to keep it alive with their cries; but during the whole day I saw only a few small birds and two or three ducks. 'Dismal,' truly."<sup>3</sup> It was not long that pleasure boats of any size remained, for Union General Peck had them cut up to use as pontoons for crossing Blackwater River which lay to the west of the Dismal.<sup>4</sup>

Both canals were potentially of great strategic importance to the Confederates. The Yankees realized this and determined to seize control of them. Accordingly, they took Elizabeth City, destroying the Confederate fleet of small boats with the exception of two which fled: one, the C.S.S. *Appomattox*, was found to be two inches too wide to pass through the locks and was burned; the second, being smaller, fled up the

canal to Norfolk. The Confederates cut the banks of the canal to let the water out to make their escape but later repaired them. The Albemarle and Chesapeake Canal being threatened, they blocked it before the enemy could do so. They then proceeded to fortify South Mills to protect the other canal. The Yankees, fearing that the Confederates might send ironclads down the canal, determined to blow up the locks at South Mills. In April, with a force of three thousand men, they engaged the Confederates three miles below the town in the Battle of Camden. While they claimed a great victory and the Confederates retreated toward the canal, somehow the demolition of the lock was overlooked when the Yankees returned to Elizabeth City.<sup>5</sup> When Norfolk fell to the Yankees in May, they lost no time in renovating the Albemarle and Chesapeake Canal and making use of the other. The Dismal was officially in Union hands but in actuality was a superb area of operation for Confederate guerilla bands. They proceeded to play havoc with Yankee forces. On September 8, 1863, Brigadier General Henry M. Naglee reported that he had occupied the swamps to stop trade and communications and burned the bridges. He had rescinded the latter order and was having them repaired and was now attempting to drive out the guerillas.

These are not uniformed, and it is impossible to distinguish them from the farmers of the country. They are familiar with the country, and conceal themselves in the thickets and most unapproachable places. My men were invariably taken at a great disadvantage, and invariably the first knowledge they had of approaching danger was a volley when least expected, and which was followed by a scattering of those who thus frequently delivered a very disastrous fire. To meet these surprises in the future, I have ordered when approaching these dangerous places where an attack can be expected,

<sup>1</sup> Davis, *The Great Dismal Swamp*, p. 91.

<sup>2</sup> *Ibid.*, p. 90.

<sup>3</sup> Berry Benson Collection, Vol. 10, p. 43, University of North Carolina.

<sup>4</sup> Robert Arnold, *The Dismal Swamp and Lake Drummond* (Norton, 1888), p. 32.

<sup>5</sup> For a detailed account, see Brown, *Canal*, pp. 97-106.

some half dozen of the most influential, restless secessionists of the vicinity shall be forced to act as guides, and be placed with the advance . . .<sup>6</sup>

The importance of the railroads in the Norfolk area was recognized by both Yankees and Confederates. The Seaboard and Roanoke was the principal carrier of the vast amount of food produced by the rich farmlands in eastern North Carolina which was so necessary to the southern armies.<sup>7</sup> General Lee wasted little time in giving orders for troops to protect it.<sup>8</sup> As a connecting link to central Virginia, the Norfolk and Petersburg was equally vital.

The latter road and its dynamic president, William Mahone, played an exciting part in the early days of the war. While Norfolk was still in Confederate hands, the Gosport Navy Yard was called upon to surrender for word had been received that Union gunboats were being sent to destroy the bridges by which the railroad came into Norfolk. Mahone and a group of volunteers in flat cars immediately took up positions to guard the bridges. Finding no enemy either there or beyond, Mahone conceived an idea for capturing the navy yard. He knew that rumors of Lee's orders for troops and North Carolina militia to converge on Norfolk in order to protect the railroads had reached the Gosport commandant "So, he adopted the ruse of having the engineer of his train blow the whistle and ring the bell of the locomotive in such a manner as to give the impression that several trains, probably troop trains, were approaching. The Federal forces took the hint, and rather than risk capture in the poorly defended port, abandoned the navy yard under the cover of night. Thus, it fell to the Confederate forces, without the firing of a shot."<sup>9</sup>

In spite of such imaginative strategies, the railroads were captured when Norfolk fell in May, 1862. In 1861, the rolling stock had consisted of the following:

	Locom.	Pass. cars	Bag. & Mail	Box & flat	Sand, coal & gravel
Norfolk & Petersburg	6	3	2	80	—
Seaboard & Roanoke	10	8	3	151	12

With capitulation imminent, most of the rolling stock had been sent west.<sup>11</sup> Nevertheless, the Yankees were able to make good use of the trains. They even changed the gauge of the tracks beyond Suffolk.<sup>12</sup> They were in a far better situation to preserve the tracks for most of the rails were manufactured in the north.<sup>13</sup> There was one bad accident in April, 1863, when a locomotive on the Norfolk & Portsmouth

smashed into the drawbridge over the Elizabeth River, taking seven flat cars down with it.<sup>14</sup>

The recently published diary of Mrs. George Wallace gives an interesting description of the war-time life of those who lived in the Dismal.<sup>15</sup> The Wallaces had only one other family as close neighbors, the William Charles Stewarts at *Beechwood*. The Wallaces' plantation, *Glencoe*, had innumerable visits from the Yankees. In April 1863, they used twenty barrels of corn and almost all of the fodder but did not harm the plantation. They burned the bridge over the Northwest Canal. The Wallaces had only two hired hands with which to work the place for their slaves and even the foreman had left "for Freedom." Their largest lighter was sunk. They watched as five hundred cavalry clattered by on their way to South Mills to attack the Confederates. The Yankees were determined to clear the guerrilla activity from the area completely and had sent General Wild to accomplish it. All day long cannon could be heard to the south. Wallace was arrested, charged with "entertaining blockade runners."<sup>16</sup>

It was a wretched year for Mrs. Wallace. Even the house-servants deserted. She wrote on May 21: "Every day a lighter passes on the D. S. Canal with the negroes and their luggage . . . The lighter was so heavily laden today that the Yankee in charge would not consent to take all, so Rachel and Mahalia packed off with a cart load of luggage. The others are to go tomorrow."<sup>17</sup> As often as she could, Mrs. Wallace made the long journey to Norfolk to visit her husband in jail. Tried by a military court in June, he was found guilty, fined \$1500 and released for ninety days in July.<sup>18</sup> Passes were now required for all who entered the Dismal and, in August, the Yankees returned. Now they were selling mules, clothing, silver and other war-spoils to negroes and poor whites. The guerrillas were still active around Currituck and burning bridges. In October a Yankee unit camped at *Glencoe*, tore down the fences and ruined the fodder. They departed in November only to be followed by others, who searched for mules and horses unsuccessfully, as they had been hidden in the back pastures. Later, Mrs. Wallace wrote "our dear Old Pete horse" was taken. When two Negro regiments passed through they were harassed by the guerrillas, one of whom was caught and hanged. General Wild's troops took two women as hostages, enraging the local people even more.<sup>19</sup>

On March 1, the Wallaces heard firing and were cheered to see Yankee cavalry riding towards Deep Creek closely followed by Confederates under Colonel Ransom. The latter tore up the bridges and departed, in their turn chased by the Yankees who met them in a pitched battle at Tadmor. To avoid another such incident, the Yankees proceeded to construct blockhouses along the canal. On March 9, Negro troops replaced the white who had been camped at *Glencoe* and they were relieved in April by five hun-

<sup>6</sup> *Official Records of the Union and Confederate Armies: The War of the Rebellion* (Washington, 1880-1901), Ser. 1, XXVII, Pt. 3.

<sup>7</sup> George Edgar Turner, *Victory Rode the Rails* (New York, 1953), p. 264.

<sup>8</sup> *Ibid.*, p. 64.

<sup>9</sup> Smith, *General William Mahone . . .*, pp. 12-13.

<sup>10</sup> Angus J. Johnston, II, "Virginia Railroads in April 1861," *Journal of Southern History* 23 (August, 1957), 319.

<sup>11</sup> Turner, *Victory*, p. 272.

<sup>12</sup> Angus J. Johnston, II, *Virginia Railroads in the Civil War* (Chapel Hill, 1961), p. 142.

<sup>13</sup> Johnston, "Virginia Railroads in April 1861," *Journal of Southern History* 23 (August, 1957), 317.

<sup>14</sup> Turner, *Victory*, p. 264.

<sup>15</sup> Eleanor P. Cross and Charles B. Cross, Jr., eds., *Glencoe Diary, The War-Time Journal of Elizabeth Curtis Wallace* (Norfolk, 1968).

<sup>16</sup> *Ibid.*, pp. 20-35.

<sup>17</sup> *Ibid.*, p. 37.

<sup>18</sup> *Ibid.*, pp. 43-51.

<sup>19</sup> *Ibid.*, pp. 52-79.

dred whites. In August, news of the death of one son and the wounding of another reached the Wallaces. The diary ended in October 1864.<sup>20</sup> While similar experiences were occurring all over Virginia, the isolation of the swamp families added to their wretchedness.

In 1863 the United States Commissioner tried to collect taxes on the Dismal Swamp Canal but there was so little revenue that even the lock-keepers remained unpaid. The president and four directors of the Company resigned and no records were kept between 1862-1865 when the Union was in possession. Fortunately they appointed a Yankee sympathiser, Leroy G. Edwards, as manager. He was able to prevent much of the possible destruction by passing soldiery, but when the canal was finally returned, it showed the neglect of the three years and was in extraordinarily bad shape.<sup>21</sup> It was several years before the Canal Company partially recovered. In 1874, it was unable to pay interest on its bonds while the rival Albemarle and Chesapeake Canal declared an income of \$90,000. The Dismal Swamp Canal Company had never enjoyed such success. It had only reported a \$25,000 net profit in 1857. Its total investment was \$1,152,891.71. Revenue continued to improve slightly but still the Company remained in great financial danger. What the War had failed to wreck, the Albemarle and Chesapeake did. Small vessels were necessary in the old canal and these had been largely destroyed during the War. The new canal could accommodate almost any size vessel and there was but the one lock at Deep Creek. To add to the gloomy picture, the United States government spent large sums of money improving and repairing the new canal. It required such subsidies for, being cut through sand, the banks were continually eroded. In contrast, the older canal had firm banks and little erosion. Construction costs of the two canals were very similar.<sup>22</sup>

On May 9, 1861, the Dismal Swamp Land Company president, Tazewell Taylor, addressed as many of the shareholders as were able to attend the annual meeting. The War had commenced. Many of their shareholders were already cut off from the Dismal area. The Company had an unusually large stock of lumber on hand but shipments and sales had stopped April first. What plans should they make for the time being? Company salaries included: the president, \$300; the agent, \$1200; the inspector at the yard, \$250; and the counter, \$250. Taylor reported that "The Company owns eight mules, six negro men, and has hired for the present year six Lighter men, and seven Cart Boys—The hires amounting to about \$1200." He suggested that they fire the inspector and the counter, reduce the pay of the president and agent and keep the Negroes to protect the lumber and to work in the swamp. He reported gross sales for the year ending May 1, 1861 to be \$34,065.10 and expenditures \$21,341.31.<sup>23</sup>

The Land Company's records are scanty between 1861 and 1870. Presumably, it received some damage

and loss of revenue as did the Canal Company. There is a reference to an arrangement which John G. Wallace had with the Company in the summer of 1868. He had cut shingles on the 150 to 200 acre area known as the "green," to the east of Jericho Canal and surrounded by burnt ground and the lake. The Company had been paid \$5432.20 while he and the Company shared the cost of the railroad. He requested a continuation until the summer of 1871 but, in the event of a refusal, hoped that the Company would give him the use of the railroad which was deteriorating from lack of it. The January, 1870, report of Taylor, who was retiring as president, appears to be the earliest surviving record of that period. He remarked that there had been a considerable loss in rotten shingles and from fire in the preceding five years but added that it was no more than usual. A schooner carrying shingles had been lost but five thousand telephone poles had been ordered from Massachusetts. The Company now had four creek and lake lighters as well as six skiffs.<sup>24</sup>

In November, 1870, Wallace reported to Cary Weston, Taylor's successor, that Washington's Ditch was still without water enough for skiffs. Weston had received requests for prices on a thousand cedar telegraph poles from Western Union and there were orders for shingles, lumber, cords of wood and ties. Upon Weston's sudden death, John F. Stewart took over as temporary agent. In March, ties were sent to the Norfolk and Petersburg Railroad, lumber to New York and cypress staves to Suffolk. John G. Wallace applied for appointment as a company agent and guaranteed the stockholders six thousand a year. Unless ten thousand was cleared, he would take no salary. In the meantime, the Company was approached by a Norfolk lumber firm, Baird, Roper and Company, who offered a lease for the swamp land of twelve thousand a year, which it accepted. This arrangement lasted for many years.<sup>25</sup>

In 1877, the Virginia General Assembly passed an Act which reorganized the Land Company on a stock share basis<sup>26</sup> and in 1899, after 136 years, it was sold to William N. Camp for \$76,500.<sup>26</sup> The Camp family had come from Rutherford, North Carolina, to settle in Southampton County, Virginia, in the early part of the nineteenth century. William Camp and five of his brothers were interested in lumbering in Virginia, North Carolina and Florida. When William N. Camp took over the Land Company holdings, the stumpage was estimated at 400,000,000 board feet. He proceeded to construct fifty-nine miles of narrow gauge railway, with rolling stock of seven locomotives and logging cars.<sup>27</sup> Some of the pilings had to be driven down thirty feet to reach a firm base.<sup>28</sup> Within two years, Camp brought an unsuccessful suit against the Canal Company for withdrawing more water from Lake Drummond when the feeder ditch was enlarged. Mr. Camp conveyed the Dismal Swamp

<sup>20</sup> *Ibid.*

<sup>21</sup> Swem DS Papers, W & M.

<sup>22</sup> John C. Parker, *The Dismal Swamp, Memoranda Concerning its History and Ownership from 1763 to 1962*. Rev. ed. (Franklin, Virginia, 1963), p. 7.

<sup>23</sup> Anonymous, "Pine Products of the Atlantic Coast," *American Lumberman*, 15 June 1907.

<sup>24</sup> C. R. Mason, "Mapping in the Dismal Swamp," *The Military Engineer* 44 (March-April 1952), pp. 120-25.

<sup>25</sup> *Ibid.*, pp. 97-128.

<sup>26</sup> Platt, *Proposal*, p. 4.

<sup>27</sup> *Ibid.*, pp. 3-23.

<sup>28</sup> DSLC-DU.

land to the Camp Manufacturing Company in 1909. In 1944, this became the Chesapeake-Camp Corporation. It again changed name in 1956 when it merged with the Union Bag & Paper Corporation and became known as the Union Bag-Camp Paper Corporation.<sup>29</sup> It is today known as the Union Camp Corporation.

Less than ten years after the War between the States, an unusual visitor and forerunner of many of to come, made his way through the old Dismal Swamp Canal. Nathaniel Bishop was making his way south in his *Maria Theresa*, well known as the "Paper Canoe." He was using the inland waterway which was being developed and which so many pleasure boats would later use. He reported in his book that the banks were seven feet above the canal which was beginning to shoal in places. He was impressed by the sight of "freedmen poling flats loaded with shingles" who "roared out their merry songs as they passed." What impressed the Yankee even more was that the lock-keepers demanded no toll for canoes.<sup>30</sup> One of Bishop's many successors was Edwin Way Teale, who visited the Dismal and Lake Drummond on his way *North with the Spring* in 1950. He reported that there had been a six foot drop in the lake in the winter of 1930-1931.<sup>31</sup>

In 1886, North Carolina Governor Alfred M. Scales named W. D. Pruden commissioner to represent the state in re-running and remarking the boundaries between the counties of Camden, Currituck and Gates, and the state of Virginia. The latter was represented by the Honorable Conway R. Howard. Pruden appointed H. T. Greenleaf of Elizabeth City as engineer. He also represented the U. S. Coast and Geodetic Survey. His manuscript diary of their travails, and Pruden's report to the governor, while not so lively as that of Byrd, picture their problems quite vividly. The survey began "at the old line stone on the Dismal Swamp Canal" on November 10. This marker had been placed by the Canal Company around 1810 but had no authority behind it and, in such haphazard fashion, that it was actually four hundred and forty-four feet north of the line. The surveyors removed the markings but left the stone and implanted new markers along the correct line.

Unlike the innate suspicion between the commissioners in 1728, there was complete agreement between Pruden and Howard. As Pruden noted, "Indeed there was but little occasion for differences between us, for considering the imperfect instruments used, the survey of 1728 was remarkable for its accuracy. Any slight errors were due doubtless to their imperfect instruments, being an ordinary Surveyor's compass etc." It was just as well that the men representing both states worked in such harmony for the weather outdid itself in testing their fitness. It was said to have been one of the most severe winters ever experienced in the area. Pruden noted bitterly: "Snow or rain was almost constant from November 26th, 1886 to February 25th, 1887, while the cold was more intense than usual with us, all of which rendered the

prosecuting of the work very slow and difficult, especially through the Dismal Swamp." A three day snowstorm, starting on December 4, left twelve inches on the ground. The canal froze over and the steamers had to break the ice to get through. Even Lake Drummond froze and some of the surveying party, who had been separated from the others, had to break their way across the lake's ice. There was an eighteen inch fall of snow in January.<sup>32</sup>

The survey was completed on March 7 and only two families were affected by the new line. In Gates County, North Carolina lost Mr. Decatur Taylor and gained "Mrs. Everett, with several small children."<sup>33</sup> Pruden summarized their impressions against the historical perspective:

It is very pleasant to compare the country and the people along the line with the accounts given by Col. Wm. Byrd in his Westover papers and others, of them in 1728. Where then was virgin forest untrodden, except by the Indian and the hunter, we find now farms and farm-houses, villages and public improvements, and even the Dismal Swamp, where then were only "tangled juniper, beds of reeds . . . and man never trod before" is now penetrated by the Canal, through which steamers daily pass; while smaller canals and paths, the work of lumbermen, are seen everywhere. As evidence of the physical and material advancement of the country, it may be observed that three Rail Roads, the Norfolk Southern, the Suffolk & Caroline, and the Suffolk Lumber, cross the line and the waters of Currituck Sound, Black Water River, North River, and smaller streams are daily disturbed by steam boats and other vehicles of Commerce.

Churches and school houses everywhere prevail and instead of ignorance and immorality depicted in the accounts of those days, we find a thrifty, moral and religious people—honest, self-reliant and law-abiding—the peers of the best.<sup>34</sup>

In 1952, a geological survey party entered the swamp. Strange as it may seem, with the passage of another sixty-five years, what was left of the Dismal appeared to be not too dissimilar from what faced Pruden and his men or even Byrd's group. They were still confronted with other problems in addition to the undergrowth. Often the tripod kept sinking and the only practical way to take a sight was to kneel.

They even found some of Byrd's "Green Sea" still in evidence. When they mapped Drummond, it was found to vary in depth from eight to thirteen feet.<sup>35</sup> This was the winter of the great drought when there was but a trickle of water in the canal and the lake's shores were laid bare to uncover World War II's practice bombs ejected by pilots from Langley Field. While the swamp has suffered droughts for centuries, Brown thinks it possible that the Camp operations could well have been a factor. They had become so

<sup>29</sup> W. D. Pruden, Report to Governor Scales, December 27, 1888. Microfilm SHC #1909, University of North Carolina.

<sup>30</sup> *Ibid.*

<sup>31</sup> *Ibid.*

<sup>32</sup> Mason, "Mapping." *The Military Engineer* 44 (March-April 1952), 120-25.

<sup>29</sup> Parker, *The Dismal Swamp*, p. 7.

<sup>30</sup> Nathaniel H. Bishop, *Voyage of the Paper Canoe* (Boston, 1878), pp. 149-51.

<sup>31</sup> Edwin Way Teale, *North with the Spring* (New York, 1951), pp. 253-59.

extensive as to require many new ditches, thus adding to the drainage.<sup>36</sup>

The neglected, practically bankrupt, canal enjoyed some years of resurrection when the Lake Drummond Canal and Water Company bought it in 1892. Just prior to this a ten mile ditch from Drummond had been dredged with the idea of supplying Norfolk and Portsmouth with drinking water. Fortunately, this was abandoned when it was found that the 1787 Act provided that the lake's waters could only be drained for navigational purposes.<sup>37</sup>

Work on the canal by the new company commenced in 1896. The most modern dredges for the time were employed and the canal was both deepened and widened. New locks were made to accommodate the sixty foot width and ten foot depth. The official opening of the improved canal took place on October 14, 1899, with much pomp and excitement.<sup>38</sup> The success of the canal improvements is shown by a U.S. Census Table, quoted by Brown. In 1880, the old canal had carried only 6,731 tons of freight while the Albemarle and Chesapeake boasted 400,000. The two canals exhibited similar statistics in 1889 (78,211 vs. 316,793) but in 1906 the Dismal's canal boasted 340,135 tons while the other only carried 95,269.<sup>39</sup> Within five years this balloon of prosperity burst when the U. S. government bought the Albemarle and Chesapeake Canal to add to its inland waterway and made it toll free. The swamp canal lost practically all of its business except for some lumber shipments and pleasure craft. The Richmond Cedar Works, which was operating a large lumbering business in the Dismal, depended on its own railway to get out the logs. Gradually the canal silted up and its depth was cut to five feet.<sup>40</sup> Finally, in 1929, the government bought it for a half million dollars.<sup>41</sup> It was useful adjunct to the Inland Waterway as, being parallel to the Albemarle and Chesapeake Canal, either could be used while the other was being repaired. Again, the canal was dredged, locks re-newed or rebuilt and various other improvements made, including draw bridges. Commercial traffic continued to use the Albemarle and Chesapeake Canal but during World War II many vessels were diverted to the swamp when the submarine menace increased the use of the inland passages tremendously.<sup>42</sup>

In 1916, Walter Prichard Eaton visited the Great Dismal and described "The Real Dismal Swamp" for *Harpers*. He found the walking pleasant along the canal banks with no mosquitoes, yellow flies or even snakes, although it was May. There were many homes and farms, and he estimated that one third of the swamp had been reclaimed. On the canal there was much activity. Schooners loaded with shingles passed him. There were two steamers daily from Norfolk carrying passengers and mail. The latter was left at "Captain Wallace's place." Eaton referred to Wallace as the "squire of the swamp," and said that his family had reclaimed a square mile of swamp "by

sinking a drain under the canal to carry off the water eastward." The principal crops at *Glencoe* were corn and hay. Wallace told him of many wild cattle in the swamp which had to defend themselves from the bears there. The battle was not always unequal for he had once found the remains of both animals together. Eaton spent one night at a "hotel" at Wallacetown, a lumber camp, and another at Captain Jack's at Lake Drummond.<sup>43</sup> This appears to have been the hotel which a Captain Busby opened not long after the War between the States. At that time Busby provided daily transportation to it from Suffolk by means of a gondola, a forty foot affair decorated with a gay red and white canopy, and powered by a wood-burning steam engine. The manager then was Captain Jack Robinson, a former army cook, who ran it in "Irish style." It was very modest, with the parlor, dining-room, kitchen and bedroom all combined. Most of the clientele were hunters who seem not to have objected to this informality.<sup>44</sup>

The most recent chapter of the Great Dismal's history ends on the most cheerful note. For almost thirty years conservation groups have been interested in preserving areas of the swamp. They have been alarmed by proposals such as one which would have made of it "the Ruhr of America."<sup>45</sup> In September, 1970, the Union Camp Corporation concluded that timber operations in their Dismal holdings were proving uneconomical. They requested a study by representatives from The Nature Conservancy, a national non-profit agency which has been credited with the preservation of 374,576 forest acres. Union Camp's 49,097 acres, including Lake Drummond, had been appraised at \$12,600,000. The land was extremely valuable as farmland or for development either industrial or residential. The Conservancy had no way in which to raise such a sum, but did encourage the consideration of tax savings as well as the engendering of goodwill for the company. Meanwhile, both North Carolina and Virginia legislatures became interested in the preservation of at least part of the Dismal. Their hand was strengthened by the passage by Congress of a bill providing for a study of the possible preservation of the Great Dismal. Shortly thereafter, in January 1973, the Union Camp Corporation announced the gift of its Great Dismal Holdings to The Nature Conservancy, with the understanding that they would transfer the land to the United States Department of the Interior to be maintained as a wildlife refuge. Never before has the United States received so large a tract of land to be used for wildlife conservation. One third of the acreage was to be transferred to the government this year, the remaining land to be leased until all would be turned over by the bicentennial year, 1975.<sup>46</sup>

The land was deeded in a formal ceremony in the nation's capital on Washington's birthday, 1973. Union Camp's chairman, Alexander Calder, Jr., made the presentation supported by President Samuel M. Kinney, Jr., Director Paul D. Camp, Jr., and other company representatives. On hand to receive

<sup>36</sup> Brown, *Canal*, p. 184.

<sup>37</sup> *Ibid.*, p. 128.

<sup>38</sup> *Ibid.*, pp. 140-150.

<sup>39</sup> *Ibid.*, pp. 153-55.

<sup>40</sup> *Ibid.*, pp. 171-73.

<sup>41</sup> *Ibid.*, p. 175.

<sup>42</sup> *Ibid.*, pp. 117-83.

<sup>43</sup> *Harpers's Monthly Magazine* CXXII (December, 1910), 18-30.

<sup>44</sup> Brown, *Canal*, p. 125.

<sup>45</sup> Freston, "The Great Dismal Swamp," *Contact*, Issue one/73, Vol. 8, No. 1, pp. 1-3.

this handsome gift were Dr. Everett M. Woodman, president of The Nature Conservancy and Under Secretary of the Interior, John C. Whitaker. Mrs. Shirley Temple Black represented President Nixon's Council on Environmental Quality.<sup>46</sup> Certain protective practices will insure that this land will become a true refuge for wildlife, for it is not to be a national park. No paved road will violate it. Access will be by means of old logging roads, hiking trails and the canals. Union Camp leases to nineteen hunting clubs on the land were cancelled.

Eight federal agencies would cooperate in a survey of the Dismal, announced July 29, 1973, by the Interior Department. It would include Union Camp's gift and the Dismal Swamp Canal, now administered by the U. S. Engineers. Hydrological studies were needed to determine the optimum drainage patterns. The Assistant Secretary for fish, wildlife and parks, Nathaniel P. Reed, stated that the main object was to determine the "desirability and feasibility of protecting and preserving the ecological, scenic, recreational, historical and other resource values" of both swamp and canal. It is to be hoped that this will result in the permanent preservation of one of the few remaining truly wild areas on the Atlantic coast.<sup>47</sup>

The Nature Conservancy hoped to encourage important additions to the wildlife refuge in the Great Dismal. A major step in that direction was taken in August, 1973, with an announcement by H. S. Merseaux, senior vice-president of Georgia-Pacific Corporation, of the sale to the Conservancy of an 1834 acre tract in Camden County, North Carolina. Merseaux indicated that Georgia-Pacific had been encouraged to make the sale because of the goals of the Conservancy: "We are proud to assist in the preservation of this unusual natural area."<sup>48</sup> Having acquired all of the original eighteenth century holdings of Washington's Dismal Swamp Land Company from Union Camp, the Conservancy now seemed well on the way toward adding those of the New Lebanon Company of the same period.

In April 1976, the Weyerhaeuser Company made a gift to the nation of nearly 11,000 acres in the Great Dismal to commemorate the Bicentennial. This tract lies largely in Gates County, North Carolina, about 20 miles northwest of Elizabeth City. It was the first land to be donated under a new program called The American Land Trust, and it will be administered by The Nature Conservancy. At long last exploitation of the resources of the Great Dismal has ceased, and a major portion of it may now be preserved for the enjoyment of present and future generations. Virginians and other Americans are greatly indebted to The Nature Conservancy, the Union Camp Corporation, Georgia-Pacific, the Weyerhaeuser Company and all who have worked toward the preservation of this great natural area.

**Acknowledgments**—The authors wish to express their appreciation to the College of William and Mary, Duke University, and the University of North Carolina, for permission to quote from original manuscripts in their collections.

<sup>46</sup> *Ibid.*

<sup>47</sup> *Richmond Times-Dispatch*, 30 July 1973, pp. 3-4.

<sup>48</sup> *Ibid.*

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Manuscript received November 9, 1976

## A Technique for Initiating the Death of Standing Pine Trees

In order to study accurately the physiology and detection of stress and the insects associated with tree death, there has been need for a reliable procedure for inducing death in standing pine trees. I have developed such a technique on Virginia pine (*Pinus virginiana* Mill.), ranging in age from 40–60 years, 21–31 cm DBH (diameter at breast height), 12–18 m in height and growing in mixture with hardwoods.

The selected pine tree is first secured by at least 4 cables (.32–.64 cm wire rope), placed at midbole. The cables are put on one at a time, looped once around the bole and secured with U-bolts. After anchoring each cable by looping it under nails driven into the base of a nearby hardwood tree, the cable is stretched with a self-locking block tackle and secured with U-bolts. Care must be taken not to pull the pine tree out of its vertical position. Another set of cables (minimum of 3) are placed horizontally about one meter above the ground, between the pine and nearby hardwoods (Fig. 1).

The dying process of the tree is initiated by sawing through the bole about .3 m above the ground, using wedges to keep the kerf open. A sheet of plastic is inserted through the kerf before knocking out the wedges. The butt is secured on the stump by bracing the bole with  $2 \times 4$ 's, then wrapping the bracing with a cable secured by staples.

Normally, two trees can be treated per day in the summer by experienced men. A total of 50 trees were killed during 1968–70 and, of these, only one slightly leaning tree was wind thrown.

When this technique is used in studies of the primary attractants of bark beetles, the emission of volatile organic matter from wounds must be avoided. The main bole should be wrapped with burlap before cabling and the sawdust collected on a tarp and removed. The kerf should then be sealed with plaster and wrapped with plastic before securing the butt. Also, the studies should be conducted in apparently healthy stands during endemic bark beetle population levels.

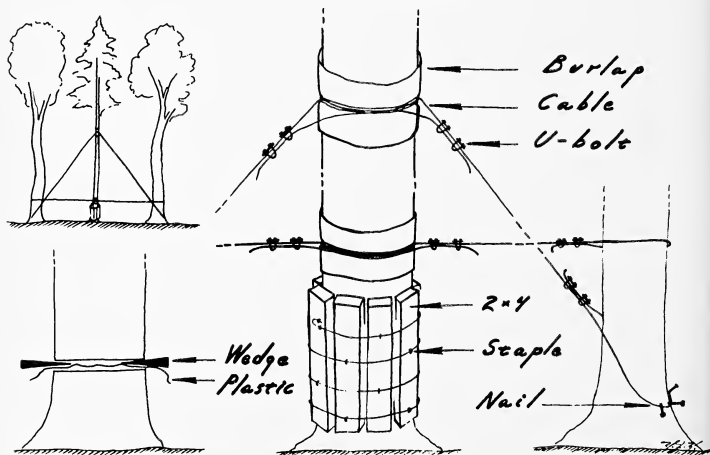


FIG. 1—A technique for initiating the death of standing pine trees.

## News and Notes

### Ivey F. Lewis Distinguished Service Award

The Award was presented to Dr. D. Rae Carpenter at the Annual Meeting of the Academy in Fairfax, on May 13, 1976, with the following citation:

This year's recipient of the Ivey F. Lewis Distinguished Service Award is a member who was introduced to the Academy by his father. He read his first paper in 1952 in the Astronomy, Mathematics and Physics section at the same time his father was to appear on the program. Both father and son served as chairmen of this section, one in 1929 and the other in 1961, one of the three father and son chairmanships in the history of this section. He has served on many committees in the Academy, some of which are the Long Range Planning, the VJAS, Finance and Endowment and Director of the Visiting Scientist program. His work has been extensive in working with high school students and teachers of this Commonwealth.

He is a native of Salem, Virginia where his father was a mathematics professor at Roanoke College. He received a Bachelor of Science degree from Roanoke College, the Master of Science degree from Cornell University and the Ph.D. degree from the University of Virginia.

His research experience has been with the U.S. Naval Weapons Laboratory, the Harry Diamond Laboratories, General Electric Company and the U.S. Weather Bureau. He has prepared a great number of technical reports since 1953 for Harry Diamond Laboratories of the Army Materiel Command and the National Oceanic and Atmospheric Administration of the Department of Commerce. For a number of years he has served as Director of the V.M.I. Research Laboratories where he serves as Professor of Physics. He is a Fellow of both the American Association for the Advancement of Science and the Virginia Academy of Science.

He was trained to respond to the standards of the Academy first by his father and then grew to love the Academy by becoming deeply involved in the section of his profession and in the responsibilities of serving as secretary, vice-president and president in 1969-70. He has shown outstanding ability as our present finance chairman and above all reflects the role of the Academy at a state level where all of us are reflected as members.

He is better known in the Commonwealth of Virginia as the Chairman of the Board of Trustees of the Science Museum of Virginia, created as a state agency in 1970 by the General Assembly. He has continued to carry the aspirations of the Virginia

Academy of Science for a state science museum since it was conceived early in the forties.

The first Distinguished Service Award was presented in 1956 to Dean Ivey F. Lewis and to William T. Sanger. Dean Lewis was described at that time as an able investigator, a master teacher, who with gentleness of manner, with kindness and understanding has labored for the advancement of science and the welfare of mankind. Our recipient has indeed followed in this manner for the welfare of the Academy.

He is one that is not only an able individual, one that works for all of us but also is one of us. He is truly a gentleman, a scientist, a teacher and leader for the work of this organization. We are indeed proud to honor him and in so doing we are honoring ourselves to present the 1976 bicentennial Ivey F. Lewis Distinguished Service Award to Delma Rae Carpenter, Jr.

### Mountain Lake Biological Station, 1977

The University of Virginia announces the following graduate courses in biology to be offered at the Mountain Lake Biological Station this summer.

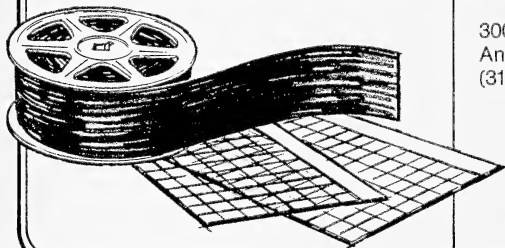
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Ornithology, Dr. David W. Johnston, University of Florida

Second Term: July 17 through August 20

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OFFICIAL PUBLICATION OF THE  
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Official Publication of the Virginia Academy of Science

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Harmon, H. H. 1960. *Modern factor analysis.* University of Chicago Press, Chicago.

Colbert, Edwin H. 1958. Morphology and behavior. Pages 27-47 in Anne Roe and George Gaylord Simpson, eds. *Behavior and evolution.* Yale University Press, New Haven.

Abbreviations of journal titles can be found in the 4th edition of the *World List of Scientific Publications* (Butterworth, Inc., Washington, D. C. 1963) and supplements. References should be checked carefully. If in doubt give the complete title of the journal.

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## The Physical Sciences in Virginia, 1609–1900

### Introduction

In the years since that morning in May, 1607, when the first British colonists disembarked at Jamestown, native and resident Virginians have made impressive contributions to the physical sciences, especially during the acceleration of scientific activity in the twentieth century.

As a bicentennial project, this paper will confine its attention to the period before 1900, when the physical sciences were slowly establishing a foothold in Virginia, leaving a record with many gaps to be filled by future historians. What is known about science in this period is still too voluminous for a paper of this nature; some favorite people and stories must be slighted. We hope you will forgive the omissions.

In the early days of the colony, science was taught under two general headings: "Natural History" and "Natural Philosophy." "Natural History," essentially nature study, flourished even before Jamestown, as the explorations of the beaches, streams, forests, and mountains led to the close observation of nature and the collection of plants, animals, rocks, minerals, shells, and other specimens, so many of them new to the explorers. The Virginia settlers, unlike those in New England, were under orders to send back to England extensive reports and whatever samples were available. Under such conditions, natural history became the pastime of notable amateurs, among them, to mention only two, William Byrd II (1674–1744) who wrote a "Natural History of Virginia" and was elected a Fellow of the Royal Society of London when only twenty-two (2), and John Clayton (1685–1773) who is remembered for his *Flora Virginica*. (10, 33). Those colonial naturalists were given solid support by the "natural history circle" in Europe, composed of some of the most distinguished scientists of the day. (37)

In contrast, "Natural Philosophy," which included what we call today the physical sciences, found limited cultivation and little support in early America. One of our distinguished historians of science, Professor I. Bernard Cohen of Harvard stated bluntly, "With the sole exception of Franklin's work in electricity, there is no contribution to pure science—whether concept, theory, law, or effect—made in any of the Americas prior to 1800 by a native or by a resident that is of such major importance that it is

worthy of being recorded in every general history of scientific thought." (11, 47b) Professor L. G. Hoxton has said, "Research in physics had a rather late start as compared with the other natural sciences. However there were lone investigators [in Virginia] in the nineteenth century." (27a) Although astronomy was taught in the colleges, and was a popular subject for lectures, significant research in astronomy in Virginia had to wait until after 1880 for the establishment of the Leander McCormick Observatory at the University of Virginia. (43a)

Before we are too critical of the early scientists of Virginia, we might look briefly at the development of the physical sciences in Europe. We find that Galileo's espousal of the Copernican World System was not published until 1632 and was then suppressed. (21) Robert Boyle's major contributions to physics and chemistry were published in 1660 (Boyle's law) and 1661 (the chemist's concept of the element). (4) Sir Isaac Newton's *Principia* came out in 1687. (38) By the time of the American Revolution, these concepts were slowly replacing Aristotelian "Physicks" in the college textbooks and classes. (31) Chemistry at this time was still encumbered by the shrouds of alchemy. Iatrochemistry (chemistry applied to medicine) was emerging. Priestley prepared oxygen from mercuric oxide in 1774. (40) Lavoisier published his *Traité* in 1789. (29) The directing influence of Dalton's atomic theory was available only after 1800. (15) Some atomic weights were in doubt until the paper of Cannizzaro in 1860. (9) Mendeleev's periodic table could then be proposed (1869). (35)

In his delightful essay on chemistry in early Virginia, William G. Guy has outlined in his inimitable way the emergence of chemistry as a science: "Chemistry began in the arts of common living, batted upon the observations of experimenters and naturalists, and developed into a science through the reflective thinking of philosophers. . . . So youthful a science is chemistry that this full gamut of progress may be witnessed in the years that lie between Jamestown and Fort Sumter." (24a)

Looking back from our vantage point of the seventies, we are reminded of the oft-quoted statement, "Ninety per cent of all scientists of all times are living today." This must be an estimate, but its significance is clear. As Raymond P. Stearns puts it, "The relative newness of present day scientific achievement is startling to contemplate." (47a) These thoughts incline us to accept the evaluation of Stearns, who argues

Dr. Trout's paper was prepared at the invitation of the Academy for the Bicentennial celebration.

that it is not good history to judge the contributions of the colonials by the standards of modern-day science. (47b)

### The Seventeenth and Eighteenth Centuries

But for a series of misfortunes, Virginia might have had the first college in the British colonies in America. The education of the young was prominent in the minds of the colonists from the earliest days. Just ten years after the landing at Jamestown, elaborate plans were under way for the establishment and support of a college at the new "planned town" of Henrico, on Farrar's Island, not far from the site of Richmond. (7) George Thorpe, a member of the King's Privy Council, was sent over to take charge of the venture. Buildings were under construction when the Indians destroyed the town in the Massacre of 1622. George Thorpe was killed. Efforts to revive the institution were ended by the revocation of the charter of the Virginia Company. Another attempt by the General Assembly to establish a college, begun in 1660, was thwarted by the scarcity of money in the colony and the restlessness of the times. (7)

It was not until 1693 that the royal charter was granted for the College of William and Mary in Virginia. Before 1710, only the Grammar School was in operation, but in 1711, according to Theodore Hornberger, "The earliest generous recognition of the sciences came at the College of William and Mary," when Tanaquil Le Fevre was appointed Professor of Natural Philosophy and Mathematics. "Le Fevre was not only William and Mary's first professor, but he was also the first man to hold a chair of science in any American college. Unfortunately, he was immediately in trouble, thanks, so Governor Spotswood said, 'to an idle hussy he brought over with him' from London. Although the Governor promptly shipped this distraction back to England, Le Fevre distinguished himself only by drunkenness, negligence of his duties and some unspecified 'irregularities' for which he was discharged in 1712." (26a)

The Reverend Hugh Jones took over the chair in 1717. "If Jones was actually teaching algebra at William and Mary between 1717 and 1722, he was among the first to introduce that subject into the college curriculum in America." (26b)

We have little knowledge of the science that was taught at William and Mary in these early days. That the College bestowed the Master of Arts degree on Benjamin Franklin in 1756, the only honorary degree granted by the College before the Revolution, speaks for some interest in science. (20a)

One professor of natural philosophy and mathematics of this period left an impression that is well documented. He was William Small (1734-75), who is remembered as "Jefferson's beloved teacher." (22) Small received the M. A. from Marischal College, Aberdeen, in 1755. On October 1758, he took over the professorship at William and Mary, replacing a man who had been dismissed by the Board of Visitors for political activities. When the Professor of Moral Philosophy was later dismissed for riotous behavior, Small took over his duties, thus becoming for a time the only professor in the School of Philosophy.

Small got on well with the authorities and the

community. He brought with him the demonstration lecture. "He was enthusiastic about his subject and was a convincing teacher as well as an ardent scientist." (20b) Thomas Jefferson, perhaps his most illustrious student, wrote half a century later in his autobiography, "It was my great good fortune and what probably fixed the destinies of my life, that Dr. William Small of Scotland was then professor of Mathematics, a man profound in most of the useful branches of science, with a happy talent of communication, correct and gentlemanly manners, and an enlarged and liberal mind. He, most happily for me, became soon attached to me, and made me his daily companion when not engaged in the school; and from his conversation I got my first views of the expansion of science, and of the system of things in which we are placed." (39)

Stearns writes, "The College of William and Mary, especially between 1758 and 1764, . . . was a lively scientific center to which the Lieutenant-Governor Francis Fauquier, F.R.S. lent prestige and support. Dr. Small led in the formation of a society founded in Williamsburg in 1759, modeled upon the Royal Society of the Arts founded in London five years before, to encourage scientific experimentation and new discoveries, arts, and manufactures. Some investigations were undertaken with niter and medicinal properties of Virginia plants, but probably the greatest accomplishment of the group was to quicken the scientific interests of Thomas Jefferson." (47c) He suggests that Jefferson's interest in science may have been implanted by his father, Peter Jefferson, well-known surveyor and cartographer. In 1751, with Joshua Fry, a professor at William and Mary, Peter Jefferson produced one of the best-known maps of Virginia.

After returning to England in 1764, Small received the M.D. from Marischal College in 1765 and moved to Birmingham, where he practiced medicine. He was a consultant to the industrialist Matthew Boulton and was associated with James Watt, the inventor of the steam engine. He was a member of the prestigious Lunar Society, which some say he was instrumental in founding.

When he returned to England, Small took with him a commission to purchase scientific equipment for the College of William and Mary. A part of the original list of apparatus in Small's own handwriting has been preserved. (20a, 32) Professors John L. McKnight and Hans C. von Baeyer, of the Department of Physics of the College of William and Mary, have made a study of this apparatus and plan to put together a lecture such as those given by Small over two hundred years ago. Dr. McKnight estimates the value of the equipment in Small's partial list at between \$3000 and \$5000 current value. (32) In the opinion of Hornberger, "Allowing for its excellent condition and Small's good judgment, it is safe to say that it was comparable to the apparatus at Harvard." (26d) Furthermore, at this time, "Harvard's greatest rival in physics was probably the College of William and Mary." (26c)

One who made good use of the apparatus purchased by Small was James Madison, a cousin of the President of the United States by the same name.



Madison graduated from the College of William and Mary in 1771, was sent to England for further study, and in 1772 returned to Williamsburg as Professor of Natural Philosophy and Mathematics. Five years later he was elected President of the College, despite the fact that he was two years under the statutory age. He retained both his professorship and the presidency until his death in 1812. He was active in the Church of England, holding many offices, including that of Bishop of Virginia. He was an ardent friend of the American Revolution. (18, 51)

During the Revolution, Madison "succeeded admirably in sustaining the interests of the College, for the exercises of the College were suspended only for a few months during the Revolution—a short time before and a short time after the siege of Yorktown." (50) With great effort the library and the equipment were spared. The London-based endowment and the overseas sources of income were lost, but extensive land holdings remained. These were added to in 1784 by the Assembly.

Thomas Jefferson, in 1779, promoted a plan to make the college into a state university, but the legislators would not cooperate. He made a second attempt after the Revolution, but it lacked the approval of the College administration. The college remained private until 1906. (14b)

Much of the credit for the recovery of the college after the war was due to the wit and effort of President James Madison. Thomas Jefferson, as a member of the Board of Visitors, proudly claimed some of the credit for the revision of the curriculum, for the novel "elective system," and for the relaxed entrance requirements. In contrast to the requirements of 1710 are those described in a letter which President Madison wrote, in 1779, to President Stiles of Yale, "The doors of ye University are open to all, nor is even a knowledge in ye ant. Languages a previous Requisite for Entrance. The students have ye liberty of attending whom they please, and what order they please, or all ye diffir. Lectures in a term if they think proper." (26e) Hornberger analyzes the program as follows: "The procedure . . . was to set up degree requirements and then abandon all machinery except, presumably, a system of advice for ambitious students and some kind of final examination." (26f)

The degree requirements as published in the laws of 1792 were as follows: "For the degree of Bachelor of Arts, the Student must be acquainted with those branches of the Mathematics, both theoretical and practical, which are usually taught as far as Conic Sections, inclusive, viz. The First six books of Euclid, plain Trigonometry, the taking of Heights and Distances, Surveying, Algebra, the 11th and 12th books of Euclid, Spherics, Conic Sections: must have acquired a knowledge of Natural Philosophy as far as it relates to the general principles of Matter, Mechanics, Electricity, Pneumatics, Hydrostatics, Optics, the first principles of Astronomy; must be well acquainted with Logic, the Belles Letters, Rhetoric, Natural Law, Laws of Nations, and the General Principles of Politics; he must also have a competent knowledge of Geography and of Ancient and Modern Languages." (13)

Jefferson said that although modern languages

were difficult to acquire there, "every other article can be as well acquired at William and Mary as at any other place in Europe." (20c)

A student has left some record of Madison's teaching in 1809. "It suggests that he kept up with new subjects, turning his attention toward chemistry rather than toward astronomy. He was somewhat more theological in his purposes than Winthrop [at Harvard] had been. Nevertheless, his course had in it elements familiar to the present-day student of physics." (26g) "His enthusiasm threw a peculiar charm over his lectures in natural philosophy." (51) Dr. Rolf G. Winter, of the Department of Physics of William and Mary, is making a study of a collection of students' notes from this period with special interest in the teaching of President Madison. (53)

During the revival of the College in 1779, a medical school was set up and Dr. James McClurg was made Professor of Anatomy, Medicine, and Chemistry. After three years the school was closed, but Professor McClurg was retained until 1800, when President Madison wrote to Jefferson: "The Professorship of Chemistry, etc., has not been actually abolished; but after Dr. McClurg left us two Professorships of Humanity were instituted in its stead. . . . At present, however, it is almost impossible to say what will be done. The Visitors seem to have abandoned the College. We have not been able to obtain a Meeting of them for five years. Such is the attention paid to science." (30a)

Although the record shows that chemistry was highly regarded at William and Mary in 1779, President Madison wrote to Thomas Jefferson ten years later, "We have no literary returns to make to you. It seems to be our Fate as yet to look to Europe for the Light of Science." (30b)

In 1801, the College of William and Mary had professors of moral and natural philosophy, mathematics, ancient languages, modern languages, law, and chemistry. There were fifty-three students. The library contained 3000 volumes. The scientific apparatus acquired by the aid of William Small in 1765 "stands in need of repairs and is less complete than at first." (26h)

By 1800, two new colleges had joined William and Mary. In 1749, the forerunner of Washington and Lee University was founded as Augusta Academy. This institution had its name changed to Liberty Hall in 1776 and received a charter in 1782. It became Washington College in 1813 and Washington and Lee in 1871. In 1800, Liberty Hall was just beginning to offer college work and was said to have good scientific apparatus.

Meanwhile, Prince Edward Academy had become Hampden-Sydney College in 1776. It was made a college by the legislature in 1783. In 1800, the College was said to have between sixty and seventy students, a library of five hundred volumes, and "small apparatus." (26i)

As the eighteenth century drew to a close, we find the enthusiasm for science that had been inspired by William Small and revived by the Reverend James Madison and Thomas Jefferson now struggling for its survival. In the next sixty years, however, before the Civil War brought education to a standstill, there was

a revival of science at William and Mary, the establishment of the University of Virginia, and the foundation of eight new colleges, events of great importance for the future of science in Virginia.

### Scientific Societies

Reference has been made to William Small's short-lived scientific society. In May, 1773, another attempt was made to establish a scientific organization in Williamsburg with the promising name of "The Society for the Promotion of Useful Knowledge." (51) John Clayton, the botanist, was the first President of the Society. The Vice-President, succeeding to the Presidency, was John Page (1743-1808). (3, 18) Page was born in Gloucester County at "Rosewell," built by his grandfather. He entered the Grammar School of William and Mary at the age of thirteen and graduated from the Philosophy School in 1763. He was a student of William Small and a friend of Thomas Jefferson, with whom he maintained a correspondence for fifty years. With his friend, David Jameson, Page studied astronomy. From his home he observed the transit of Venus, in 1769, using a pair of "perspective glasses" made by the English craftsman Ayscough and a Hadley reflecting quadrant. In 1779, Page suggested the identity of magnetism with electricity and he invented an instrument for measuring the fall of dew and rain to 1/300 inch. (3) He said of himself, in his autobiography, that he was too sociable to shut himself off in solitude for study as did his old friend Thomas Jefferson. (18) Nevertheless, he was elected to the legislature, served as Lieutenant-Governor and Governor, was congressman from Virginia from 1789 to 1797, and performed other services for his state and his country.

The Society for the Promotion of Useful Knowledge, unfortunately, did not survive the Revolution. An attempt in 1783 by Monsieur de Beaurepaire to organize an Academy of Arts and Sciences in Richmond was also unsuccessful. (24b) Thus Virginia was left without the stimulus of a vigorous scientific society until the early twentieth century.

### The Early Nineteenth Century

After the turn of the century, physical sciences were gaining a secure footing in Virginia before the cataclysm of the Civil War. So much interest developed that Dr. Lyon G. Tyler, in his paper, "Virginia's Contribution to Science," written in 1915, was led to say, "The current of the 19th century sets in strongly and the limits of my paper confine me to a very brief mention of names." (51)

At the College of William and Mary, James Madison remained as President and Professor of Natural Philosophy until his death in 1812. In this year John McLean was appointed Professor of Chemistry. McLean had studied with Black in Edinburgh. He had also studied in London, and then in Paris, where he met Lavoisier.

In 1795 he became the first Professor of Chemistry at Princeton University. He was a vigorous proponent of Lavoisier's views on combustion. Unfortunately, he lived only two years after arriving in Williamsburg. (18)

The remarkable Rogers family, father and four

sons, brought great talent to science in America. The father, Patrick Kerr Rogers, arrived in Williamsburg in 1819, succeeding Robert Hare, who had moved after one year to the University of Pennsylvania. Rogers had fled Ireland after the repression of the Rebellion of 1798, in which he had participated. He studied medicine and chemistry at the University of Pennsylvania then "migrated toward Jeffersonianism." Rogers and his four sons, James Blythe, William Barton, Henry Darwin, and Robert Empie, had a profound influence on the course of physical science in America and especially in Virginia. "They were a good-looking and closely knit set of men, who often collaborated with each other in their scientific work; the published correspondence between William and Henry casts important light on the scientific growth of America during the pre-Civil War days." (49a)

James Blythe Rogers studied under his father at William and Mary, studied medicine, then turned to chemistry and eventually succeeded Robert Hare as Professor of Chemistry at the University of Pennsylvania. Henry Darwin Rogers also received his early training from his father. He taught chemistry for a while, became a geologist and collaborated with his brother William on several surveys. He moved to Edinburgh in 1855 and was appointed Regius Professor of Natural History at the University of Glasgow, where he remained until his death. His appointment marked the beginning of the School of Geology at Glasgow. (18)

William Barton and Robert Empie Rogers taught in Virginia and we shall return to them later.

The father, Patrick Kerr Rogers, has been described as "a cultured man who kept alive the scientific interest aroused by Jefferson in the natural resources of Virginia." (49b) We have some idea of his teaching from a book that he published in 1822, "An Introduction to the Mathematical Principles of Natural Philosophy." (41) Rogers continued the tradition of the lecture demonstration and was able to obtain additional apparatus valued at \$3000. (32)

When Patrick Rogers died in 1828, his second son, William Barton Rogers, assumed his post. William had studied with his father, had attended the public schools in Baltimore, and had graduated from William and Mary in 1822. For a while, he and his brother Henry conducted a school at Windsor, Maryland, and in 1827-28, he was a lecturer at the Maryland Institute. (18) Student notebooks have been preserved that give an insight into his course in chemistry at the College of William and Mary. No evidence of a physics course has been found. (32)

When William Barton Rogers accepted the appointment as Professor of Natural Philosophy and Geology at the University of Virginia in 1835, his replacement at William and Mary for the next thirteen years was John Millington, the son of an English attorney. After a varied career which included a lectureship at the Royal Institution, association with Birbeck and the Mechanics Institution, Millington was appointed by the University of London the first Professor of Engineering. Because the Council of the University refused to guarantee a salary of £ 400 a year, he resigned the post before the University actually opened. (16)

His biographer says of him that he "approached greatness, though at a respectable distance," (18) only to spend the next forty years in restless wandering. Just before coming to Williamsburg, he conducted a shop for the sale of scientific "machines, instruments, apparatus, and materials," in Philadelphia. When he was made Professor of Chemistry, Natural Philosophy, and Engineering at William and Mary, he brought some of his equipment with him. Leaving Virginia in 1848 to become the first Professor of Chemistry and Technology at the University of Mississippi, he eventually was impoverished by the Civil War and found his way to Richmond, where he lived with his daughter until his death. He is buried in the church yard of Bruton Parish in Williamsburg. (18)

On Millington's departure from William and Mary, his duties were added to those of the Professor of Mathematics, Benjamin Ewell. Ewell was able to obtain an additional \$2000 worth of scientific equipment in 1848-50. McKnight says, "From this and such fragmentary evidence as correspondence between Ewell and Rogers and between Ewell and ex-President John Tyler, it is clear that science continued to enjoy strong support." (32) Unfortunately, on Tuesday, February 8, 1859, fire destroyed the library of 20,000 volumes, including gifts from Sir Isaac Newton and Louis XVI of France. Nearly all the scientific equipment was destroyed.

Rebuilding the College was undertaken by Ewell, who was then President. William Barton Rogers, from Boston, sent "quite a handsome collection of apparatus." But, McKnight writes, "The rebuilt College never really had a chance to flourish. The secession of Virginia, which John Tyler had worked so hard to avert, came about. The College put its endowment in Confederate war bonds and faculty and students went to war under former President, now Colonel Ewell." (32)

Meanwhile, an event of great importance for the future of science was the founding of Thomas Jefferson's University of Virginia. With the aid of Joseph C. Cabell and over the opposition of Charles Fenton Mercer, Jefferson prevailed upon the legislature to underwrite his plans for a state university. (14a) It was chartered in 1819 and its doors were opened in 1825. Virginius Dabney states, "Its invigorating influence upon education in the South exceeded that of any other university throughout the nineteenth century." (14a) Historian Herbert Baxter Adams said, the University is "the noblest work of Jefferson's life." Thomas P. Abernathy wrote, "No early American save Mr. Jefferson would have dared to house a university in Roman temples, to employ a majority of foreign professors, to exclude the clergy and all their theologies." (14a)

Jefferson lived slightly more than a year after the University opened its first session. "He rejoiced to see his dream come true, but the last months of his life were saddened by the riotous behavior of the students. Their conduct grew even worse somewhat later, when Gessner Harrison, chairman of the faculty was horsewhipped, and John A. G. Davis, his successor as chairman, was fatally wounded by a pistol-wielding undergraduate." (14a)

Jefferson's interest in science ranged over agriculture, botany, ethnology, geography, paleontology, and others. His interest in chemistry is well documented. (5) His library contained books by Chaptal, Duhamel, Fourcroy, Hales, Ingen-Housz, Lavoisier, Parmentier, Rumford, Scheele, Wallerius, Watson, and other prominent chemists. While minister to France, during the years 1784-1789, Jefferson met many of the European scientists. A letter written from Paris to his friend, the Reverend James Madison, tells of his predictions for the future of chemistry: "Speaking one day with Monsieur de Buffon, on the present ardor of chemical inquiry, he affected to consider chemistry but as cookery, and to place the toils of the laboratory on a footing with those of the kitchen. I think it, on the contrary, among the most useful of sciences and big with future discoveries for the utility and safety of the human race." (5, 24c)

While he was Secretary of State, in March, 1791, Jefferson carried out experiments with the help of David Rittenhouse, President of the American Philosophical Society; Casper Wistar, Professor of Chemistry at the College of Philadelphia; and James Hutchinson, Professor of Chemistry at the University of Pennsylvania, designed to test the proposal by Jacob Isaac, of Newport, Rhode Island, for a novel process of obtaining fresh water from salt by distillation using a secret additive. The experiments showed that the secret additive was not necessary to the process. This "Report on the methods for obtaining fresh water from salt" was the first document of a chemical nature to be published by the United States Government. (6, 19a)

Jefferson sought and obtained the help of many people in the establishment of his university, among them the Reverend Joseph Priestley, who had escaped further religious persecution in England by moving to Northumberland, Pennsylvania, in 1794. At Jefferson's request, Priestley wrote a long letter, which he titled, "Hints concerning public education," offering advice concerning the curriculum and administration of the University. Among the nine subjects recommended is "Chemistry, including the theory of agriculture." (46) It is interesting to find that many of Priestley's suggestions were adopted by Jefferson. In fact, Jefferson made chemistry even more important than Priestley had envisioned it. In a letter to the first Professor of Natural Philosophy at the University, Dr. John Patton Emmet, written on May 2, 1826, only two months before his death, Jefferson suggested a course including one dozen lectures each in botany, zoology, mineralogy, and geology, and eight dozen lectures in chemistry. "You will say that two thirds of a year, or any better estimated partition of it, can give but an inadequate knowledge of the whole science of Chemistry. But consider that we do not expect our schools to turn out their alumni already enthroned on the pinnacles of their respective sciences; but only so far advanced in each so as to be able to pursue them by themselves, and to become Newtons and Laplaces by energies and perseverances to be continued through life." (5)

Professor Emmet remained at the University from 1824 to 1842. He began the tradition of research and publication that has characterized the Department of

Chemistry to this day. During his eighteen-year incumbency, he published some half-dozen papers. (24d)

In 1835, William Barton Rogers became Professor of Natural Philosophy and Geology, while Emmet took over the chemistry. Rogers also was official geologist of the State. Assisted by his brothers, he directed the Virginia Geological Survey from 1835 to 1842. "He was a popular teacher, able to fascinate an audience by his accounts of astronomy and geology, then so popular in the country." (49c) In a student's account of one of his lectures, "At this period of his life he is described as tall in stature, 'with a figure of the type known to us through the picture of Henry Clay,' a man without arrogance but of a singularly commanding face, and without a peer among his fellow scientists in addressing an intelligent audience." (49d)

With his brother Henry, William ventured into the field of dynamic geology, proposing a theory of the unfolding of the Appalachian mountain chain, which they presented to the Association of Geologists in Boston in 1842. (49e)

William Barton Rogers was elected Chairman of the Faculty, a position then equivalent to the presidency. "This position heightened Rogers' administrative and organizational interests and afforded him the opportunity to evaluate Jefferson's ideals in an expanding America. These ideals stressed the full use of science and technology for the betterment of man's state." (49f) In a report on the state of the University in 1845, Rogers praised Jefferson's elective system.

While at the University, Rogers published a few papers in physics, covering topics in electricity, sound vortex rings, aurorae, binocular vision, phosphorescence, and others. The leading American physicist Joseph Henry said of him, "He is one of those who, not content with retailing the untested opinions and discoveries of European philosophers, endeavor to enlarge the boundaries of useful knowledge by experiments and observations of his own." (27b)

Unhappy with developing conditions in Virginia, Rogers resigned from the University in 1853 and moved to Boston. As a result of Rogers' vigorous campaigning, the Massachusetts legislature in 1861 granted a charter for the Massachusetts Institute of Technology. The Institute opened its doors in 1865 with Rogers as its first President. Rogers retired in 1870 but remained associated with the Institute, dying during a commencement address that he was giving to a graduating class in 1882.

The youngest of the Rogers brothers, Robert Emmet, succeeded John P. Emmet in 1842 as Professor of General and Applied Chemistry at the University. Robert was only fifteen when his father died and he was taken in charge by his brothers James and William. First active in engineering, he turned to medicine, graduating from the University of Pennsylvania in 1836. While at the University he had spent much time in the laboratory of Robert Hare. His interest in chemistry finally led him to give up his medical practice to become the first chemist of the Pennsylvania Geological Survey, of which his brother Henry was at that time the head. He moved to the University of Virginia to accept "a position involving the kind of

work best suited to his tastes and abilities—teaching and investigating." (18) "His teaching was characterized by dexterity in experiment and lucidity in exposition; moreover he was sincerely interested in the every-day life of the students and in turn was beloved by them. His investigations during this period were mostly done in collaboration with his brother William. Together they devised a new method for preparing chlorine, improved processes for making formic acid and aldehyde, and perfected a method of determining carbon in graphite. They studied the volatility of potassium and sodium carbonates, the decomposition of rocks by meteoric water, and the absorption of carbon dioxide by liquids, the last-named investigation being a helpful contribution to the analysis of mineral waters. About this time, with his brother James, he studied the alleged insolubility of copper in hydrochloric acid and also published a textbook of chemistry (1846), a compact work compiled from contemporary books of English authors." (18) When his brother James died in 1852, Robert succeeded him as Professor of Chemistry at the University of Pennsylvania.

J. Lawrence Smith, who followed Rogers in the fall of 1852, remained at the University only one year, resigning in 1853 "to live on his income." During that year, he and his assistant, George J. Brush, carried out a "Reexamination of American Minerals," which was published in a series of papers in the *American Journal of Science* between 1853 and 1855. They also made significant contributions to analytical methods.

Smith, who had studied at the University of Virginia for two years, 1835-37, had received the M.D. degree from the Medical College of South Carolina, and had spent several years in Europe, studying with such teachers as Liebig, Orfila, Dumas, and Elie de Beaumont. Back in Charleston, he took up medical practice and became interested in soils. This interest led to an appointment by James Buchanan, then Secretary of State, as advisor on cotton culture to the Turkish Empire. On arrival in Turkey, he became interested in mineral resources and ended making a survey of emery and coal deposits. Returning to the United States, he spent two years studying and teaching in New Orleans, then, in 1852, he came to the University of Virginia.

After leaving Virginia, Smith worked and lectured at the Smithsonian for a year, then spent twelve years as Professor of Medical Chemistry and Toxicology at the University of Louisville.

Smith's bibliography lists 145 separate papers. He was President of the American Association for the Advancement of Science in 1872 and followed Draper as the second President of the American Chemical Society. He was a member of the National Academy of Sciences. He was decorated by France, Russia, and Turkey. Benjamin Silliman, the elder, considered Smith the first noteworthy organic chemist of America. (18) Smith's biographer says of him, "Although he was neither magnetic, charming, nor eloquent, and never a great teacher, he was a bold thinker and one of the ablest chemists of his time." (18)

Socrates Maupin, a native of Albemarle County, succeeded Smith and remained at the University for

eighteen years. He had graduated from Washington College in 1828, received the M.D. from the University of Virginia in 1830, and had stayed on to study liberal arts, obtaining the M.A. in 1833. After teaching ancient languages at Hampden-Sydney College, he was for a while the principal of an academy in Richmond and then head of his own classical school. He joined in the founding of the Medical Department of Hampden-Sydney College (later the Medical College of Virginia) and in 1847 became its Dean. He accepted the chair of Chemistry and Materia Medica at the University of Virginia in 1853 and served the University until his death in 1871. He was chairman of the faculty from 1854 to 1870, the longest tenure on record. His colleagues on the faculty said that "it was largely due to him that the prostration during the war was not a fatal and remediless blow to the University." (34)

In addition to the courses offered by Professor Maupin, laboratory work in analytical chemistry was available as early as 1857 under the supervision of Dr. David K. Tuttle, then Instructor in Chemistry, who remained on the staff until 1862.

The chair of Natural Philosophy was assumed by Francis Henry Smith in 1852 and he remained active until 1906. He used the lecture demonstration method of teaching. In 1870 he introduced a course in "Practical Physics" designed for students who wished to become teachers of the subject. It was available on demand and covered such procedures as the construction of demonstration apparatus, the maintenance of equipment, and methods of measurement. Instruction was also available in the theory of measurements.

Meanwhile the earliest existing catalogue (1826) of Washington College lists Edward Graham as Professor of Astronomy, Natural Philosophy, and Chemistry. In this same year, the John Robinson chair of Natural Philosophy was established. Landon C. Garland and Joseph W. Farnum were incumbents for short terms. In 1838, George Dod Armstrong became Robinson Professor of Physical Science. He used the lecture system, illustrated with demonstrations by the professor. The catalog lists the textbook as Turner's *Chemistry*. The catalog also called attention to a "respectable amount of chemical and philosophical apparatus, valued at \$5000, which was kept in good order."

In the opening lecture of a series delivered in Washington College in 1838, Armstrong refers to the youthfulness of chemistry as a science and makes the striking statement that man "had noted on his chart the place of each principal fixed star; he had marked out the orbits of the planets—before he was acquainted with the composition of the water with which he slaked his thirst." (24d) Armstrong resigned in 1851 to become the pastor of the First Presbyterian Church of Norfolk, where he remained for the rest of his life. He was succeeded by John Lyle Campbell, a member of a family closely related to the College. He served for thirty-five years, "becoming one of the strongest teachers on the faculty." (23)

Hampden-Sydney College has had a professor of chemistry since 1821, when Jonathan P. Cushing was appointed. One professor destined to become the first

President of the American Chemical Society, John William Draper, was at the College only three years, but while there he began experiments that were to bring him lasting fame.

Draper majored in chemistry at the University of London, studying under Edward Turner. Through the courtesy of Professor Alwyn G. Davies, of the Department of Chemistry of the University of London, we have received a copy of the original examination "for prizes and certificates of honour," set by Dr. Turner and completed by John W. Draper during the session 1829-30, with pencil marks indicating the questions that Draper answered. This examination provides an interesting insight into the chemistry of the time. The original examination was given to the University of London by Draper's great grandson, Daniel C. Draper, of New York. (16)

After the death of his father, Draper's family moved to Mecklenburg County, Virginia. Determined that John should study medicine, his sister Dorothy gave him the money to attend the University of Pennsylvania, where he received the M.D. in 1836. While at the University he was attracted to Robert Hare and spent time studying chemistry and physics. The invitation to become the Professor of Chemistry and Natural Philosophy at the Hampden-Sydney College enabled him to "convert experimental investigation, thus far only an amusement, into the appropriate occupation of his life." (1, 18)

Draper was a pioneer in photography. He improved Daguerre's method by adding bromine to the iodine in the process. Bunsen and Kirchhoff recognized Draper's leadership in spectrum analysis. He may have been the first in America to have a diffraction grating, made for him by Joseph Sartori of the U. S. Mint. He had far-reaching scientific interests.

Draper moved in 1839, as Professor of Chemistry, to the University of the City of New York, later New York University. There he made substantial contributions to the development of the medical school, of which he became President in 1850. He was the first President of the American Chemical Society, which was founded on April 6, 1876, at the "College of Pharmacy of the City of New York, University Building, corner Waverly Place and University Place." (44) The Society celebrated its Centennial in New York City on April 4-9, 1976, with memorial exercises that included the placing of a time capsule in the wall on the site of the original building.

No history of science in Virginia would be complete without mention of Matthew Fontaine Maury, "The Pathfinder of the Seas." Matthew, the fourth of five sons of Richard and Diana Maury, was born near Fredericksburg. When only five years old, he was taken with his family to Tennessee, near the frontier town of Franklin. Following his brother's lead, he secured a Midshipman's warrant in 1825 and in nine years made three important cruises. In 1834 he obtained leave, married Ann Hull Herndon, and published "A New Theoretical and Practical Treatise on Navigation," which appeared in 1836 and met with immediate favor. This resulted in his promotion and assignment as astronomer to the Exploring Expedition to the South Seas. He was not happy with the choice of leadership, however, and obtained reas-

signment to surveying duty in the harbors of the southeastern states. It was at this time that he published articles critical of the Navy, using the pseudonym, "Harry Bluff." He survived this episode and was made Superintendent of the Naval Observatory. Maury's interests were mainly in the hydrographic and meteorological aspects. He immediately began his research on winds and currents. In 1847 he published his "Wind and Current Chart of the North Atlantic," which was followed by the "Abstract Log for the Use of American Navigators" (1850), and "Explanations and Sailing Directions to Accompany the Wind and Current Charts" (1851). Maury's title was changed in 1854 to Superintendent of the U. S. Observatory and Hydrographic Office.

The success of these studies encouraged mariners to cooperate with Maury in noting winds and currents. Eventually a uniform system of recording oceanographic data was adopted by the International Congress in Brussels in 1853, largely as a result of Maury's labors.

Mariners who used these charts were able to save fifteen or more days in passage from New York to Rio de Janeiro and their value was spectacularly shown during the gold rush, when the time required between New York and San Francisco was cut from 180 days to 133 in 1855. Other reductions resulted in the saving of millions of dollars annually.

The first textbook of modern oceanography, "The Physical Geography of the Sea," which went through numerous editions and half a dozen translations, was published by Maury in 1855. Maury and his assistants developed methods for deep sea sounding that permitted the construction of a profile of the Atlantic Ocean, of fundamental assistance to Cyrus Field in the laying of the telegraphic cable.

Maury received many honors. In fact, he was so popular that his peers in the Navy passed him over for promotion. Support came from many sources and finally the President of the United States made Maury a Commander and restored him to the Service. (19b)

Three days after the secession of Virginia, on April 20, 1861, Maury resigned his commission and was immediately made Commander of the Confederate States Navy. He was sent to England as a special agent and was in the West Indies when the Confederacy collapsed. Amnesty was not granted to representatives abroad, so Maury went to Mexico, where he hoped to bring other Confederates to form a colony. The scheme was abandoned after a year. Maury went to England, where he resumed work on electric mines and wrote geographies for school use. He was awarded the Ph. D. degree by Cambridge University.

Maury returned to the United States in 1868 as Professor of Meteorology at the Virginia Military Institute. His "Physical Survey of Virginia, No. I" was published in that year. Maury taught until his death in 1873. (18)

The Civil War brought the end of academic life in Virginia. Faculties were dispersed, buildings were often occupied by troops, scientific apparatus was removed, and restoration of the institutions after the war was hampered by lack of funds. Higher education reviewed, however, and the growth and maturation

of scientific studies were apparent in the years before World War I.

### Post-War Recovery

The period following the Civil War, before 1900, saw the beginning of fundamental studies in astronomy at the University of Virginia, the clear recognition of physics as a separate discipline in the schools, and the consolidation of chemistry by the foundation of the American Chemical Society.

The future of astronomy in Virginia was established in 1870, when Leander J. McCormick, a native of Rockbridge County, offered a large telescope, first to Washington and Lee University, which could not accept it, and then to the University of Virginia. A dozen years passed before the funds necessary to supplement Mr. McCormick's gift could be secured. In 1882, Ormond Stone became the first Director of the Leander McCormick Observatory, with what was at that time the largest refracting telescope in the world. It was equipped with a 26 1/4 inch lens, ground by the famous Alvan G. Clark. For the first thirty years the telescope was used with considerable success as a teaching tool. (43b) Research was stepped up in 1913 under S. A. Mitchell and has been accelerated in recent years with the opening of the new observatory on Fan Mountain.

To assist Socrates Maupin with applied chemistry after the war, an outstanding chemist came to the University. John William Mallet was born in Ireland, studied chemistry at the Royal College of Surgeons, and entered Trinity College in 1849. In that year he published a "Notice of New Chemical examination of Killinite" in the Journal of the Geological Society of Dublin.

Mallet earned the Ph. D. degree under Wöhler at Göttingen in 1852. The following year he was awarded the A.B. degree by Trinity College. Meanwhile, he had assisted his engineer father with experiments on velocity of shock-transmission from gunpowder explosions through rock and loose earth. He had also commenced a "Catalogue of Recorded Earthquakes from B.C. 1606 to A.D. 1842," reported to the British Association for the Advancement of Science.

Coming to America, Mallet served as Assistant Professor of Analytical Chemistry at Amherst College for several months in 1854. He was chemist for the State Geological Survey of Alabama in 1855-56. In 1862 he published a report on an exhaustive study of the cultivation of cotton. When the War broke out, Mallet enlisted in the Confederate Army, served as an officer under General Robert E. Rodes, and in 1862 was given general supervision of the ordnance laboratories of the Confederacy.

Following the War, after surveying petroleum in Louisiana for some northern capitalists and teaching for a year in the university of Louisiana Medical School, Mallet was appointed in 1867 Professor of Chemical Technology and Agricultural Science at the University of Virginia and given charge of the School of Analytical Chemistry and the Chemical Laboratory. At that time Socrates Maupin was Professor of

Chemistry, Francis Henry Smith Professor of Natural Philosophy, and Charles S. Venable Professor of Mathematics. With the exception of two years, 1883-1885, when he taught at the University of Texas and the Jefferson Medical College, Mallet remained at the University of Virginia until his death in 1912.

As a lecturer, Mallet was systematic, concise, and clear in his presentation and explanation of facts. He insisted that each of his students make some investigations and add his fragment to the sum total of knowledge.

More than one hundred publications are listed, concerning compounds, minerals, and chemical and physical phenomena. In 1881 Mallet conducted investigations of drinking waters, which were published in the Annual Report of the National Board of Health. Mallet was a member of the Assay Commission in 1886, 1888, and 1896. He was a member of the International Committee on Atomic Weights in 1899, a member of the International Congress of Applied Chemistry in Berlin in 1903 and in Rome in 1906. In 1877-78 Mallet lectured at the Johns Hopkins University. He was a member of several foreign chemical societies, was a Fellow of the Royal Society of London, and was one of the founders of the American Chemical Society, of which he was President in 1882. (18)

By the end of the nineteenth century, chemistry was clearly established as a discipline and was strongly supported by national and international societies. Physics was a separate discipline. According to Professor Hoxton, research in physics "in a serious way began in 1897 with the work of W. J. Humphreys on the pressure shift of arc spectra." (27c) Until 1888 geology had been listed in the catalogue under Natural Philosophy. In this year the Corcoran School of Geology was established with William M. Fontaine as Professor of Natural History and Geology.

With regard to mathematics, Dean T. McNider Simpson quotes Dr. H. R. Phalen, then of the faculty of the University of Virginia, "It was no accident that in later life Jefferson saw to it that mathematics held a more important place in the curriculum of the University of Virginia than it enjoyed at other American colleges of the period." (43b) Dean Simpson writes further, "While the teaching of mathematics in Virginia colleges has been competent and in many cases excellent, research in pure mathematics was little emphasized prior to the return from Europe of James Morris Page. Educated at Randolph-Macon College and a student of the Norwegian Sophus Lie at Leipzig, [Page] joined the faculty of the University of Virginia in 1896. He introduced to America Lie's method of application of parameters and groups to the study of differential equations, by his own published textbooks on the subject and the researches of some of his students. His duties as an administrative officer prevented his devoting much time to the directing of research. . . . The University entered its most productive period of research in the middle thirties." (43b)

Dean Simpson tells another interesting story: "Possibly the most distinguished mathematician whose name is associated with Virginia is J. J. Syl-

vester, once Professor of Mathematics at the University of Virginia. This brilliant and eccentric young Jew came to the University from the faculty of the University of London in the fall of 1841, but he soon ran afoul of student rudeness which he was unwilling to tolerate and resigned before the year was over. More than thirty years later he returned to America as one of the able group of scholars who made up the first faculty of the Johns Hopkins University." (43c)

In 1900 there were in Virginia some twenty institutions of higher learning. Notable among them was the Virginia Agricultural and Mechanical College (now the prestigious Virginia Polytechnic Institute and State University), which opened its doors in 1872 and after some difficulties was well established by 1900. Each of these institutions had professors of the disciplines making up the physical sciences. A fair number of these professors were actively engaged in research and many others devoted to it what time they could salvage from teaching loads and administrative duties. Their story makes interesting reading.

Looking back we see that at the end of the nineteenth century the physical sciences were just beginning to show something of the excitement and activity that were to follow in the twentieth century. Stearns writes, "Americans made enviable progress during the nineteenth century in *applied sciences*—in engineering and technology—but it was the twentieth century before they equaled, and ultimately surpassed, the science of the Old World." (47d) During the first three-quarters of the twentieth century, activity in the physical sciences in Virginia increased, gradually at first, then at a rate that certainly would have astonished even the most optimistic scientist of the nineteenth century. The steady progress after World War I, the acceleration during and after World War II, and the post-Sputnik "explosion" all merit a chronicle of major proportions.

#### *Acknowledgments—*

I am deeply indebted to a number of people who gave their time and thought to this paper, especially to the following: the staff of the Library of the University of Richmond, especially Miss Kathleen B. Frances, Reference Librarian, and Mrs. Katherine R. Smith, Science Librarian; the staff of the Virginia State Library; the staff of the Richmond Public Library; Miss H. J. Parker, Deputy Keeper, the Library of the Science Museum, London; Professors J. Samuel Gillespie, Jr., W. Allan Powell, and James E. Worsham, Jr., Department of Chemistry, University of Richmond; Professor Frances W. Gregory, Department of History, University of Richmond; Professor Alwyn G. Davies, Department of Chemistry, University of London; Professor John H. Wise, Department of Chemistry, Washington and Lee University; Professors John L. McKnight, Hans C. von Baeyer, and Rolf G. Winter, Department of Physics, College of William and Mary; Professor Dorothy C. Bliss, Chairman of the Committee, for her patience, understanding, and valuable suggestions; and finally, to my wife, Harriet, and my two sons, William E. Trout, III, Ph.D., and Stran L. Trout, J.D., for their patience, encouragement, and the careful reading of the manuscript.

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Manuscript received January 9, 1976

Revised manuscript received March 30, 1977

## A Multiattribute Utility Function For Management of a Recreational Resource<sup>1</sup>

**Abstract**— An outdoor recreational experience has several attributes. Keeney's methodology of multiattribute utility functions was used to discover tradeoffs between attributes and the importance of increments in each attribute for management of a small rural sport fishery. The utility function describes the preference orderings of a hypothetical decisionmaker such as a regional manager. Using the methodology, the objective function for management of a recreational stream fishery was expressed as a function of species of fish caught, average size of fish caught, average number of fish caught, and average number of anglers on the stream per day. Alternative sets of parameters for the utility function were tested in a simulation-optimization model to show sensitivities of the parameters in terms of the optimal management strategy.

### Introduction

Rational management of a recreational natural resource by a public agency requires maximization of an objective function which reflects benefits to the user as well as to society as a whole. The objective most often used by public agencies is user-day maximization (McFadden 1969) primarily because it is easily quantifiable. However, many attributes may enter into the recreational experience (Moeller and Engelken 1972). In the example of a recreational fishery, important attributes of an individual's fishing experience may include water quality, scenic beauty of the area, size, number, and species of fish caught, privacy, support facilities, and access to the fishing area. Moeller and Engelken (1972) found in their sample that anglers consistently ranked privacy higher than either number or size of fish in the catch. Such results lead us to conclude that user-days is a measure of benefit to the agency rather than to the individual user.

An alternative procedure for developing an objective function is for the decision-maker to specify certain measures of effectiveness and then develop a utility function governing explicit measures or attributes. Given such a utility function, the expected utility may be calculated, and this would be the objective function; the decision-maker would prefer the alternative with the greatest expected utility (Halter and Dean 1971, Raiffa 1970, Von Neumann and Morgenstern 1947). Such a utility function is an ex-

pression of preference and sufficient conditions for its existence may be verified (see, e.g., Henderson and Quandt 1971:13).

The present study derives a utility function of several attributes for the management of a sport fishery in a small rural stream (Rich Creek, Monroe County, West Virginia) using the model and procedures of Keeney (1974). The utility function describes the preference orderings of a hypothetical decision-maker, such as a regional manager employed by the West Virginia Department of Natural Resources. This utility function was used in a simulation-optimization model in which maximization of the sum of utility over a year was the objective. This presentation will focus on (1) measurement procedures of the utility function; (2) tradeoffs between the attributes of utility function; and (3) ramifications of the choice of utility parameters in terms of optimal management strategy for the stream.

### Study Area

Rich Creek begins as a spring rising in Monroe County, West Virginia, and runs 17.7 km south, passing through Peterstown, West Virginia, and the town of Rich Creek, Virginia, and draining into the New River. The Rich Creek watershed has an area of 85 km<sup>2</sup>, the majority of which is pasture land, although some of it is planted in corn. The stream is characterized at average flow by water depths of 0.5 to 0.8 m and an average width of 4.7 m.

The stream is classified as a marginal trout stream by the West Virginia Department of Natural Resources. Trout are available from two sources: (1) the State of West Virginia regularly stocks the stream with trout of catchable size in the later winter months, and (2) a few trout escape during high water from a private hatchery located at the headwaters. No natural reproduction of trout occurs in the stream.

Recreational fisheries in the stream include heavy angling (300–500 angler hrs/ac/yr) for trout and a small amount of fishing for bluegill and smallmouth bass, which have reproducing populations in the stream.

Field studies (Brandt and Schreck 1975) were designed to mimic commercial harvest of bait species by licensed bait fishermen common in the area. These

<sup>1</sup> Financial support was received from the West Virginia Department of Natural Resources and the National Marine Fisheries Service (PL88-309, Contract No. 04-3-043-11). We gratefully acknowledge the constructive criticisms of Dr. Robert B. Jensen, Virginia Polytechnic Institute and State University.

fishermen used seines and traps to capture live bait which was sold to recreational fishermen.

### Simulation Model

The simulation model and optimization procedures are considered in detail by Powers (1975), but a summary will be presented here. The simulation model consists of a set of nonlinear, time-dependent difference equations which were updated at 24 stages of simulated time with each stage being 15 days in length. Thus, the time was approximately 1 year (January to December). At each updating, fish population abundance, natural mortality, natality, ration size, growth, average weight, and biomass were calculated for each age-class of each fish species. Catch of each fish age-class by each of the five angler categories (trout, bluegill, and bass anglers, seine-users, and trap-users) was also calculated, as well as the concentration of fishermen using the stream.

The following decision variables governed the rate of exploitation of fish populations by commercial and recreational fishermen: minimum and maximum size limits for bluegill and smallmouth bass; possession number limits for trout, bluegill, smallmouth bass, and baitfish; stocking rate of trout; number of commercial fishermen; length of seines; seine and trap mesh size; and proportion of the stream open to fishing. These variables were time-dependent and were integrated into appropriate portions of the simulator.

The objective of the optimization problem was to find the combination of decision variables which maximizes the time-stream of utility over the year; i.e., maximizes the sum of utility over the 24 time stages, where the utility function represented the recreation fishing criterion in the decision problem. In conjunction with this objective, three terminal (year-end) constraints were considered: (1) a limit was placed on the yearly expenditures (costs of stocking trout in the stream); (2) a minimum level of catch by commercial baitfishermen was specified (minimum level of the time-stream of catch/seine/day); and (3) to avoid overexploitation a minimum level for the year-end value of an ecological diversity index was specified.

The optimization algorithm used was a heuristic procedure which combined aspects of search by regression (Schmidt and Taylor 1972) and the discrete maximum principle (Wilde and Beightler 1967:425-444). The algorithm involved fitting transition functions to simulation data, and then solving for the approximate optimal policy by the discrete maximum principle. With the newly derived policy, a new simulation was performed and new transition functions were fit. The iterative procedure was continued until convergence occurred. A more detailed account of this algorithm is given by Powers (1975).

### The Utility Attributes

Several measures of effectiveness or attributes were chosen to reflect the recreational fishing experience in the utility function. These were:

$X_1$  = fish species appearing in the catch/angler/day  
 $X_2$  = average size of fish in the catch/angler/day

$X_3$  = average number of fish caught/angler/day  
 $X_4$  = number of anglers/day

The species attribute,  $X_1$ , was defined to be a vector ( $X_1^{TR}$ ,  $X_1^{SMB}$ ,  $X_1^{BG}$ ) corresponding to trout, smallmouth bass, and bluegill, respectively. For example, a member of  $X_1^{TR}$ , called  $x_1^{TR}$ , could only take on the value zero if no trout were caught, or one if some trout were caught (regardless of number), and similarly for  $x_1^{SMB}$  and  $x_1^{BG}$  (Table 1). Thus, by definition the most preferred outcome of  $X_1$ , was  $x_1 = (1,1,1)$  corresponding to all three species appearing in the catch.

$X_3$  was the attribute of number scaled from zero to one. The scaled value of  $x_3$  (a member of  $X_3$ ) was calculated in the following fashion: let us say the average angler caught 13 trout, 1 smallmouth bass, and 3 bluegill. From Table 1, it can be seen that the maximum number he could have caught would be 20 trout, 20 smallmouth bass, and 30 bluegill. When each of these is expressed as a percentage of the maximum and then averaged, we have  $x_3 = (13/20 + 1/20 + 3/30)/3 = (0.80)/3 = 0.267$ .

Similarly,  $x_2$  (a member of  $X_2$ ) was calculated by a weighted average. Assume the average angler caught 3 trout, each 10 inches long, 4 smallmouth bass, each 11 inches long, and 5 bluegill, each 7 inches long. A 10-inch trout, when expressed as a percentage of the possible range, is equivalent to  $(10-8)/(14-8)$  or 0.333 (Table 1). Likewise, an 11-inch smallmouth equals  $(11-9)/(16-9)$  or 0.286 and a 7-inch bluegill is  $(7-5)/(12-5) = 0.286$ . The mean scaled length for all fish caught is  $x_2 = [3(0.333) + 4(0.286) + 5(0.286)]/(3+4+5)$ ; i.e.,  $x_2 = 0.295$ . Attributes  $X_2$  and  $X_3$  were scaled from zero to one to eliminate their dependence on the species attribute.

The attribute  $x_4$  was a measure of crowding (or conversely, privacy) and it also was converted to a

TABLE 1  
Utility attributes and their ranges

Attribute	Least desirable amount	Most desirable amount
Species in catch (Yes = 1, No = 0)		
$X_1^{TR}$ : trout	0	1
$X_1^{SMB}$ : smallmouth bass	0	1
$X_1^{BG}$ : bluegill	0	1
$X_1$ : scaled	0	1
Average length of fish caught (inches) /angler/day		
trout	8	14
smallmouth	9	16
bluegill	5	12
$X_2$ : scaled	0	1
Average number fish caught/angler/day		
trout	0	20
smallmouth bass	0	20
bluegill	0	30
$X_3$ : scaled	0	1
Number of anglers/day (No./500 yd <sup>2</sup> /day)		
$X_4$ : scaled	50	0
	0	1

scale of zero to one (Table 1). For example, 15 anglers/500yd<sup>2</sup>/day was expressed as  $x_4 = (50-15)/50 = 0.7$ , because 15 is 70% of the range for  $X_4$ .

Given the four attributes which contribute to our "quality of recreational fishing" criterion, we desired to construct a utility function  $u(x_1, x_2, x_3, x_4) \equiv u(x)$  reflecting all of these measures. Experience by other investigators (Keeney 1973) has indicated that varying more than two attributes simultaneously makes utility assessments extremely difficult for decision-makers. Therefore, we wished to identify and verify assumptions that would allow us to find a function  $f$  such that

$$u(x) = f[u_1(x_1), u_2(x_2), u_3(x_3), u_4(x_4)], \quad (1)$$

where  $u_i(x_i)$  is a utility function over attribute  $X_i$ . With the assumptions verified, then (1) could be defined by measuring the  $u_i(x_i)$  and scaling factors which indicate tradeoffs between attributes. The model, assumptions, and assessment procedures which we used were developed by Keeney (1973, 1974).

### Assumptions

Let  $X = X_1 \times X_2 \times X_3 \times X_4$ ,  $X_{ij} \equiv X_i \times X_j$ , and  $X_{24-} \equiv X_2 \times X_4$  (read as "ex not two four"). Let  $x$  be a member of  $X$  and  $x_{24-}$  a member of  $X_{24-}$ .  $X_{i-}$  is the Cartesian product of all attributes except  $X_i$  with  $x_{i-}$  being a member of  $X_{i-}$ . Designate  $x_i^0$  as the least preferred outcome of  $X_i$  and  $x_i^*$  as the most preferred outcome with  $u_i(x_i^0) = 0$  and  $u_i(x_i^*) = 1$ . Also,  $u(x_i^0, x_{2-}^0, x_3^0, x_4^0) = 0$  and  $u(x_i^*, x_{2-}^*, x_3^*, x_4^*) = 1$ .

The assumptions which allow the development of (1) are preferential independence and utility independence. Preferential independence implies that if an outcome  $(x_i, x_j, x_{ij-})$  is preferred to some other outcome  $(x_i', x_j', x_{ij-})$  for a specific  $x_{ij-}$ , then it is preferred for any  $x_{ij-}$ . Utility independence implies that preferences for lotteries held over  $x_i$  with  $x_{i-}$  held fixed do not depend on  $x_{i-}$ , i.e., the conditional utility functions over  $X_i$  are positive linear transformations of each other (Keeney 1974),

$$u(x_i, x_{i-}) = g(x_{i-}) + h(x_i)u_i(x_i) \quad (2)$$

where  $g$  and  $h$  are positive scalar functions.

The assumptions were verified by discussions with several members of our Department who took the role of decision-maker during these interviews. As an example, consider whether  $X_2$  (size of fish) and  $X_3$  (number of fish) are preferentially independent of  $X_1 \times X_4$ . First, we fixed  $X_{14}$  at a fairly desirable level ( $x_1$  = trout, only;  $x_4$  = 5 anglers/500 yd<sup>2</sup>/day). Then, we questioned the decision-maker to find an  $x_3$  such that  $(x_3, 11)$  was indifferent to  $(15; 9)$ ; i.e.,  $x_3$  fish caught, average size of 11 inches was indifferent to 15 fish caught, average size of 9 inches. Let us say the amount of  $x_3$  chosen was eight fish. The exact number was not important for verification, only its change with changes in the other attributes. Next, we set  $x_{14}$  at trout, only, and 30 anglers/500 yd<sup>2</sup>/day and repeated the above procedure. Once again, the amount of  $x_3$  chosen was eight fish. Then, we changed  $x_{14}$  again and got an equivalent answer on the  $X_3$  scale. At this point we could ask if the value of  $x_3$  would

hold for any  $x_{24-}$ . The affirmative answer implied preferential independence of  $X_2$  and  $X_3$ .

Similarly, the utility independence of  $X_i$  with  $X_{i-}$  was verified. Let us examine the utility independence of  $X_4$  (privacy) with  $X_{4-}$ , as an example. First  $x_1$  was set at trout, only;  $x_2$  at 9 inches; and  $x_3$  at 3 fish. Then the decision-maker was asked for an  $x_4$  which would make him indifferent to  $x_4$  anglers for certain or a 50-50 lottery yielding zero anglers or 50 anglers. Let us say  $x_4$  = five anglers was chosen. Next,  $x_1$  was set at bluegill, only;  $x_2$  at 10 inches; and  $x_3$  at 20 fish. The decision-maker was again asked for the number of anglers for certain that would make him indifferent to the 50-50 lottery. Five anglers were chosen again. In general the decision-maker agreed that his response did not depend on fixed amounts of  $X_{4-}$ . This result plus testing of other lotteries verified that  $X_4$  was utility independent of  $X_{4-}$ .

Given the validity of the two assumptions, Keeney (1974) proved that the utility function took the form

$$u(x) = \sum_{i=1}^4 k_i u_i(x_i) + K \sum_{i=1}^4 \sum_{j>i} k_i k_j u_i(x_i) u_j(x_j) u_n(x_n) + \dots + K^3 k_1 k_2 k_3 k_4 u_1(x_1) u_2(x_2) u_3(x_3) u_4(x_4), \quad (3)$$

where the  $k_i$  are scaling factors ( $0 < k_i < 1$ ) and  $K$  is another scaling factor ( $-1 < K$ ). When  $x_i = x_i^*$  and  $x_{i-} = x_{i-}^0$ , i.e., when attribute  $i$  is at its most preferred amount and all other attributes are at their least preferred amounts, then  $u(x) = k_i$ . If  $\sum k_i = 1$ , then  $K = 0$  and (3) reduces to

$$u(x) = \sum_{i=1}^4 k_i u_i(x_i). \quad (4)$$

otherwise, when  $\sum k_i \neq 1$  then  $K \neq 0$  and (3) can be algebraically manipulated to yield

$$1 + Ku(x) = \prod_{i=1}^4 [1 + Kk_i u_i(x_i)]. \quad (5)$$

The species attribute  $X_1$ , was defined to be a vector  $(X_1^{TR}, X_1^{SMB}, X_1^{BG})$ . Therefore, once the three elements of  $X_1$  were shown to be preferentially and utility independent,  $u_1(x_1)$  could be expressed as

$$u_1(x_1) = \sum_{j=TR, SMB, BG} c_j u_1(x_1^j), \quad (6)$$

or

$$1 + Cu_1(x_1) = \prod_{j=TR, SMB, BG} [1 + Cc_j u_1(x_1^j)], \quad (7)$$

where the  $c_j$  and  $C$  are scaling constants equivalent to  $k_i$  and  $K$  in (4) and (5). The utility over attribute  $x_1^j$  is denoted by  $u_1(x_1^j)$ . Since  $x_1^j$  can only take on the values one or zero, corresponding to species  $j$  appearing in the catch or not, then  $u_1(x_1^j)$  will also only equal one or zero. Therefore,  $u_1(x_1)$  was completely defined when the scaling constants  $c_j$  and  $C$  were determined.

### Method of Evaluating Scaling Factors

As was mentioned previously,  $k_i = u(x_i^*, x_{i-0})$ . Therefore, each  $k_i$  could be evaluated by finding the probability  $p$  at which the decision-maker was indifferent to  $u(x_i^*, x_{i-0})$  for certain and a lottery offering  $u(x^*)$  with a probability  $p$  or  $u(x^0)$  with a probability  $1 - p$ . The results yield

$$u(x_i^*, x_{i-0}) = p[u(x^*)] + (1 - p)[u(x^0)]. \quad (8)$$

Since  $u(x^*) = 1$  and  $u(x^0) = 0$ , then (8) reduces to

$$u(x_i^*, x_{i-0}) = p, \quad (9)$$

and the scaling factor  $k_i$  is equal to  $p$ . Similar procedures are used to find the scaling factors  $c_j$ .

If  $\sum_i k_i \neq 1$ , then  $K \neq 0$  and must be evaluated. The scaling factor  $K$  may be found numerically by solving

$$1 + K = \sum_{i=1}^4 (1 + Kk_i) \quad (10)$$

for  $K$ . Equation (10) is derived from (5) when all attributes are offered at their most preferred amounts; i.e.,  $x = x^*$ . If  $\sum_i k_i > 1$ , then  $-1 < K < 0$ ; and if  $\sum_i k_i < 1$ , then  $K > 0$ . Thus, (10) may be easily solved by trial and error. The scaling factor  $C$  may be found in an analogous fashion.

### Utility of Each Attribute

The utility of each attribute  $u_i(x_i)$  had to be determined as well. Since  $u_i(x_i)$  was completely defined by the scaling factors, utility assessment was only needed for  $\bar{X}_2$ ,  $\bar{X}_3$ , and  $\bar{X}_4$ . The model chosen to express this was

$$u_i(x_i) = x_i^{b_i}, \quad (i = 2, 3, 4), \quad (11)$$

where  $b_i$  are constants. The form of (11) was chosen because we desired a simple smooth function which fit the boundary conditions for  $x_i$  and  $u_i(x_i)$  and for which estimates of the parameters could be easily made. Since part of the study was to determine ramifications of the choice of parameters, the restrictive form of (11) was acceptable.

The utilities could be assessed by asking the decision-maker:

- (1) What certainty equivalent of length of trout (in inches) would make you indifferent to the lottery offering a 14-inch trout and an 8-inch trout, each with equal probability?
- (2) What certainty equivalent of numbers of bluegill/angler/day will make you indifferent to a lottery offering 30 bluegill/angler/day and 0 bluegill/angler/day, each with equal probability?
- (3) What certainty equivalent of number of other fishermen/500 yd<sup>2</sup>/day will make you indifferent to a lottery offering 50 other fishermen/500 yd<sup>2</sup>/day and 0 other fishermen/500 yd<sup>2</sup>/day, each with equal probability?

The responses to the three questions when scaled from zero to one may be termed  $x_2$ ,  $x_3$ , and  $x_4$ , respectively. Then  $u_i(x_i)$  may be expressed as

$$u_i(x_i) = 0.5[u_i(x_i^*)] + 0.5[u_i(x_i^0)] \\ = 0.5 \quad i = 2, 3, 4.$$

Therefore, using (11)

$$u_i(x_i) = 0.5 = x_i^{b_i},$$

and may be found by

$$b_i = \ln [0.5] / \ln [x_i].$$

### Parameterization of the Utility Function

A utility function represents the decision-maker's personal preferences, and there is no "right" or "wrong" associated with it. However, by the very nature of his position a decision-maker employed by a public agency is required to make value judgements about benefits to the public whom the agency serves. In all likelihood, preference orderings by the users will not be consistent. Even if they were, it is unlikely that the decision-maker's utility responses would completely coincide with those of the public. Therefore, by definition the decision-maker must decide on the utility responses himself.

However, the decision-maker may have no *a priori* judgments of marginal utilities and tradeoffs which will affect public benefits. In such a case public input may be desirable. Sinden (1974) used utility measurements of members of the public to value recreational experiences. Morris (1974) notes that preferences of a panel of experts should be viewed as *information* by the decision-maker. Therefore, a sample of the public's (panel of experts') preferences may provide input to the decision-maker before he makes his utility responses.

Using this argument, we wished to have some public input into the utility function. Therefore, we sent 225 questionnaires to residents of Monroe County, West Virginia, who had purchased fishing licenses. Responses to the questionnaires provided initial estimates of the scaling factors and the  $u_i(x_i)$ . In order to simplify the questionnaires, the technique for calculating the  $k_i$  and  $K$  was modified (see Appendix). However, the response rate to the questionnaires was still low (11%), indicating the difficulty of obtaining utility information from questionnaires. Interviews might have given the respondents a better understanding. Also, although we had no way of knowing if the respondents were representative of the fishing public, the questionnaires did give initial indications of feasible parameter values. Use of these initial parameters and subsequent perturbations in the simulation model were designed to determine if physical and biological characteristics of the stream fishery would show some of the utility parameters to be less sensitive than the others in terms of the optimal management strategy.

TABLE 2  
Parameter values for the utility function

Parameter	Value	Parameter	Value	Parameter	Value
$k_1$	0.384	$c_{TR}$	0.800	$b_2$	1.710
$k_2$	0.473	$c_{SMB}$	0.750	$b_3$	0.387
$k_3$	0.449	$c_{HG}$	0.600	$b_4$	34.314
$k_4$	0.424	$C$	-0.976		
$K$	-0.833				

From the median of the responses to the questionnaires, initial estimates of the parameter values were made (Table 2). The utility of attribute size [ $u_2(x_2)$ ], number [ $u_3(x_3)$ ], and privacy [ $u_4(x_4)$ ] showed increasing, decreasing, and increasing marginal utilities, respectively (Figure 1). The marginal utility of privacy was highly increasing, indicating that reductions in crowding will not significantly increase utility for the median respondent unless crowding is already low. The utility for the outcomes of the species attribute [ $u_1(x_1)$ ] showed that trout was the most preferred species, then smallmouth bass, then bluegill; and combinations of the three reflected this initial preference (Table 3).

The rank order of the  $k_i$  derived from the median questionnaire response showed that  $k_2 > k_3 > k_4$ , indicating privacy was less important than numbers or size of fish. This rank order and the highly increasing marginal utility of privacy found from the median response were corroborated by observations of rather high crowding conditions in Rich Creek when trout were recently stocked. Tradeoffs between attributes and indifference curves are established in Figure 2.

The parameter values derived from public input (Table 2) completely specify the form of the utility function. It was assumed that our hypothetical decision-maker would first test these parameter values in the simulation model, and next test alternative values to determine the sensitivity of the parameters. Since  $\sum c_i \neq 1$  and  $\sum k_i \neq 1$ , the proper forms of the utility functions are multiplicative over  $x$  and over  $x_i$ ; i.e., equations (5) and (7). Thus, the objective was to maximize the sum of (5) over all 24 time stages; i.e.,

$$\max UT = \sum_{t=1}^{24} u(x_1, x_2, x_3, x_4). \quad (12)$$

The cumulative sum objective (12) carries several

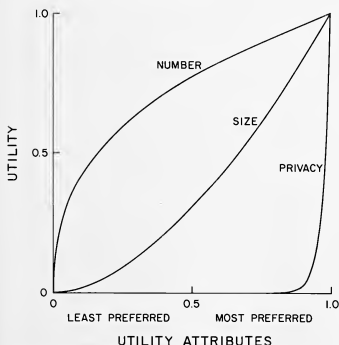


FIG. 1.—Utility derived from  $X_2$  (Size),  $X_3$  (Number), and  $X_4$  (Privacy) as found from the median questionnaire response.

TABLE 3  
Utility for the eight outcomes of  $u_1(x_1)$

Species in catch			$x_1$	$u_1(x_1)$
trout	smallmouth bass	bluegill		
No	No	No	(0,0,0)	0.000
No	No	Yes	(0,0,1)	0.600
No	Yes	No	(0,1,0)	0.750
Yes	No	No	(1,0,0)	0.800
No	Yes	Yes	(0,1,1)	0.911
Yes	No	Yes	(1,0,1)	0.932
Yes	Yes	No	(1,1,0)	0.964
Yes	Yes	Yes	(1,1,1)	1.000

implicit assumptions. First, since time is not an attribute in the utility function, no discounting takes place. For a 1-year time-horizon this assumption seems reasonable. Secondly, the sum assumes that a time series of utility of (0.5, 0.5, 0.5) is equally desirable as one of (1.0, 0, 0.5); i.e., no disutilities are associated with fluctuations. This may not be valid in many instances.

### Simulation Results

We tested 14 sets of utility parameters (Table 4) in the simulation-optimization model, including the original set specified in Table 2. Two basic management strategies evolved from these optimization experiments. These two strategies will be termed the Multispecies Strategy (MS) found to be applicable to Programs VII and XIII (Table 4) and the Trout Strategy (TS) found for all other programs. These terms are not meant to be totally descriptive, but rather they are used to establish nomenclature. The time sequence of  $x_i$  ( $i = 1, 2, 3, 4$ ) was found by optimization and these sequences for TS and MS (exemplified by Programs I and VII, respectively) are presented in Figure 3.

Trout was the primary exploited species in TS except for a short period when bluegill were also harvested. The numbers harvested gradually increased over the year due to an increased stocking rate. Increased angling pressure (time stages 10–14) caused all of the trout that were stocked within a time period to be caught within that same time period. The fishery became a "put and take" trout fishery. Therefore, the trout had no opportunity to grow in size while they were in the stream. The result was that the size attribute ( $X_2$ ) decreased over time. After time stage 12 all of the fish that were harvested were trout and all were at the least preferable size, i.e. the size at which they were stocked. The attributes of privacy ( $X_4$ ) and numbers ( $X_3$ ) increased later in the year to compensate for the small fish being caught.

Programs VII and XII produced the other strategy (MS) due to a high tradeoff associated with size of fish ( $k_2$ ) and due to an increasing marginal utility of numbers ( $b_3 > 1$ ) respectively (Table 4). When  $b_3 > 1$ , more fish/angler are harvested early in the fishing season because a unit increment in  $X_3$  will produce a more than 1-unit increment in utility. To allow increases in  $X_3$ , all species were harvested during stages

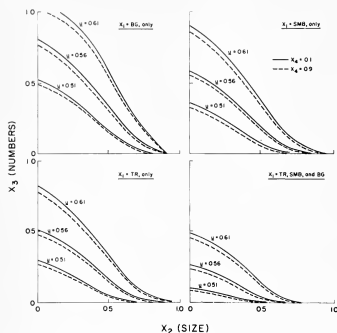


FIG. 2—Tradeoffs between the four utility attributes and the indifference maps, derived from median questionnaire response.

9 and 10. The bluegill and smallmouth bass being caught at this time were large, thus  $X_2$  was high as well.

Conversely, when  $k_2$  is high, larger fish must be harvested. The strategy to allow this (Figure 3) was to induce exploitation of all species. Since the bluegill and smallmouth bass were in abundance during stages 9 and 10, the result was large values for  $X_3$ . This argument is the rationale for two seemingly different programs. (VII and XIII) producing the same management strategy (MS).

The Multispecies Strategy resulted when  $k_2$  was very large in relation to the other  $k_i$  and when the marginal utility of numbers was changed from decreasing to increasing. The Trout Management strategy was less sensitive to changes in other utility parameters. Recognizing these sensitivities, the decision-maker could use the median utility param-

eters of the public sample as his own utility parameters in which case the TS would be expected to result. If the decision-maker chose to modify his parameters according to Programs VII and XIII, then the MS would be expected.

### Conclusion

An outdoor recreational experience such as sport fishing will have several attributes. These attributes should enter into the objective function in the management of such a recreational system. Even if the uses of the recreational resource by people preferring different attributes are separated "in space or time," the manager of the system will ultimately have to make tradeoffs between attributes when allocating his management effort. Keeney's methodology (1974) of multiattribute utility functions described herein appears to be a good way of discovering the relative magnitude of these tradeoffs and the importance of increments in each attribute.

We have described the use of this methodology in conjunction with a simulation-optimization procedure for determining management strategies for a stream fishery. We also introduced a rational basis for including public input into this process. Although the utility function reflected only one criterion (angler benefits) in this particular example, other criteria such as conservation, commercial fishermen benefits, and agency benefits could be included, as well. Also, if independence can be shown, these criteria could be arranged in hierarchies with one utility function being an attribute of another. If several attributes are included in the management objectives, the public is more likely to obtain the quality outdoor recreational experiences that are desired.

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TABLE 4  
Optimal cumulative utility (UT\*) found by using alternative sets of utility parameters in the simulation model

Program	$C_{TR}$	$C_{SMB}$	$C_{BG}$	$k_1$	$k_2$	$k_3$	$k_4$	$b_2$	$b_3$	$b_4$	UT*
I	0.80	0.75	0.60	0.384	0.473	0.449	0.424	1.710	0.387	34.314	7.668
II	0.50	— <sup>a</sup>	—	0.544	0.331	0.307	0.282	—	—	—	6.860
III	0.50	—	—	0.486	0.313	0.283	0.499	—	—	—	7.412
IV	—	0.50	—	—	—	—	—	—	—	—	7.728
V	—	—	0.90	0.748	0.116	0.113	0.109	—	—	—	7.143
VI	—	—	—	0.679	0.237	0.215	0.194	—	—	—	7.386
VII	—	—	—	0.467	0.575	0.272	0.238	—	—	—	7.769
VIII	—	—	—	0.470	0.307	0.540	0.240	—	—	—	7.034
IX	—	—	—	0.556	0.331	0.209	0.282	—	—	—	7.367
X	—	—	—	0.473	0.307	0.274	0.506	—	—	—	8.375
XI	—	—	—	—	—	—	—	3.000	—	—	7.667
XII	—	—	—	—	—	—	—	—	0.100	—	9.099
XIII	—	—	—	—	—	—	—	—	1.500	—	8.001
XIV	—	—	—	—	—	—	—	—	—	5.000	8.024

<sup>a</sup> Dash denotes the same numerical value as in Program I.

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## Appendix

Respondents to the utility questions had difficulty in interpreting the scaled attributes  $X_3$  and  $X_4$ ; e.g., they did not understand that 15 bluegill and 10 smallmouth bass were the same value in  $X_3$  (Table 1). Therefore, the questions were modified to avoid this confusion.

Remember that  $x_i = (x_i^{TR}, x_i^{SMB}, x_i^{BG})$ , thus the notation  $x_i = (1, 0, 0)$  denotes smallmouth bass, only, are appearing in the catch. Also remember  $X_{34} = X_3 \times X_4$ ,  $X_{34-} = X_1 \times X_2$ ,  $x_3^*$  is the most preferred amount of  $X_3$ , and  $x_3^0$  is the least preferred amount of  $X_3$ . If a respondent is indifferent to  $x$  for certain, and a lottery of  $x'$  with a probability  $p$  and  $x''$  with a probability  $1 - p$ , then

$$u(x) = p[u(x')] + (1 - p)[u(x'')]. \quad (A-1)$$

The values of  $k_i$  ( $i = 1, 2, 3, 4$ ) and  $K$  were found from the following four questions:

- Find  $p_1$  such that the respondent was indifferent to  $[x_1 = (1, 0, 0), x_{1-}^*]$  for certain, or a lottery offering  $[x_1 = (1, 0, 0), x_{1-}^*]$  with a probability  $p_1$  and  $[x_1 = (0, 0, 1), x_{1-}^*]$  with a probability  $1 - p_1$ .
- Find  $p_2$  such that the respondent was indifferent to  $[x_1 = (0, 0, 1), x_2^*, x_{24}^*]$  for certain, or a lottery offering  $[x_1 = (1, 0, 0), x_{1-}^*]$  with a probability  $p_2$  and  $[x_1 = (0, 0, 1), x_{1-}^*]$  with a probability  $1 - p_2$ .
- Find  $p_3$  such that the respondent was indifferent to  $[x_1 = (0, 0, 1), x_3^*, x_{34}^*]$  for certain, or a lottery offering  $[x_1 = (1, 0, 0), x_{1-}^*]$  with a probability  $p_3$  and  $[x_1 = (0, 0, 1), x_{1-}^*]$  with a probability  $1 - p_3$ .
- Find  $p_4$  such that the respondent was indifferent to  $[x_1 = (0, 0, 1), x_4^*, x_{4-}^*]$  for certain, or a lottery offering  $[x_1 = (1, 0, 0), x_{1-}^*]$  with a probability  $p_4$  and  $[x_1 = (0, 0, 1), x_{1-}^*]$  with a probability  $1 - p_4$ .

Because there was never more than one non-zero element in  $x_i$ , the respondent did not have to convert number and length scales from one species to another.

From the first question and using (A-1), we obtain:

$$u[x_1 = (1, 0, 0), x_{1-}^*] = p_1(1 + Kk_1c_{TR}) + (1 - p_1)(1 + Kk_2)(1 + Kk_3) \\ (1 + Kk_4) + (1 - p_1)(1 + Kk_1c_{BG}) \quad (A-2)$$

From (5) and (7) in the body of the paper it can be stated that

$$1 + Ku[x_1 = (1, 0, 0), x_{1-}^*] = 1 + Kk_1c_{TR}$$

or

$$u[x_1 = (1, 0, 0), x_{1-}^*] = k_1c_{TR} \quad (A-3)$$

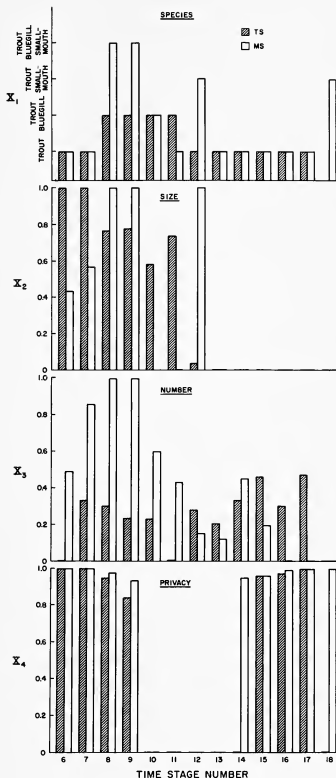


FIG. 3.—Time sequence of optimal attributes found by the simulation model. TS is the Trout Strategy. MS is in the Multispecies Strategy. Time stage six corresponds to late March and stage 18 corresponds to late September.

When (A-3) and (A-2) are equated, we get:

$$k_1c_{TR} = p_1(1 + Kk_4c_{TR})(1 + Kk_2) \\ (1 + Kk_3)(1 + Kk_4) + (1 - p_1)(1 + Kk_1c_{BG}) \quad (A-4)$$

Similarly, responses to questions 2, 3, and 4 produce probabilities  $p_2$ ,  $p_3$ , and  $p_4$ ; therefore,

$$u[x_1 = (0, 0, 1), x_i^*, x_{11}^-] = p_i(1 + Kk_1c_{TR})(1 + Kk_2)(1 + Kk_3)(1 + Kk_4) + (1 - p_i)(1 + Kk_1c_{BG}) \quad (A-5)$$

for  $i = 2, 3, 4$ . We know from (5) and (7) that

$$\begin{aligned} 1 + Ku[x_1 = (0, 0, 1), x_i^*, x_{11}^-] \\ = (1 + Kk_1c_{BG})(1 + Kk_i) \end{aligned}$$

or

$$\begin{aligned} u[x_1 = (0, 0, 1), x_i^*, x_{11}^-] \\ = k_1c_{BG} + k_i + k_1k_1c_{BG}K \end{aligned} \quad (A-6)$$

for  $i = 2, 3, 4$ . Equating (A-5) and (A-6) gives

$$\begin{aligned} k_1c_{BG} + k_i + k_1k_1c_{BG} = p_i(1 + Kk_1c_{TR})(1 + Kk_2)(1 + Kk_3)(1 + Kk_4) \\ + (1 - p_i)(1 + Kk_1c_{BG}) \end{aligned} \quad (A-7)$$

for  $i = 2, 3, 4$ . We also know that

$$1 + K = (1 + Kk_1)(1 + Kk_2)(1 + Kk_3)(1 + Kk_4). \quad (A-8)$$

Equations (A-4), (A-7), and (A-8) are five equations in the five unknowns  $k_i$  ( $i = 1, 2, 3, 4$ ) and  $K$ . These may be solved by an appropriate numerical technique, such as fixed point iteration (Conte 1965:43). This does not guarantee a unique solution. However, in practice several choices of the initial  $k_i$  and  $K$  in the solution technique produced the same solution. Also, the bounds on  $k_i$  and  $K$  are rather closely defined ( $0 < k_i < 1$ ,  $-1 < K$ ). Therefore, with some justification it was assumed that the solution obtained was unique.



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Manuscript received February 23, 1976

Revised manuscript received May 5, 1977

## A Technique for Improving Decision Analysis in Fisheries and Wildlife Management

**Abstract**—Computer implemented modeling has clearly benefited managers in industrial and military management positions. Improvements in the cost effectiveness of computer use should allow fisheries and wildlife managers to make increasing use of computerized decision models. A modeling technique developed for industrial purposes to utilize the full state of knowledge of a decision problem is presented here and proposed for use in fisheries and wildlife management. The technique uses the Weibull function for subjective probability assignment to help solve the problem of making decisions based upon incomplete or inadequate data.

An effective and realistic fisheries and wildlife manager must consider economic, political, technological, and biological components of the system he manages. Any one of these components can be difficult to understand, so it is no surprise that fisheries and wildlife management can be, and usually is, extremely complex. Management personnel would welcome analytical techniques which have the potential to improve efficiency and effectiveness. Computer implemented modeling is one such technique. Simulation and other types of modeling can be applied, with the aid of a computer, to help identify optimal decision policies for complex systems. Computer assisted modeling has received wide application in the military and industrial complexes (Schmidt and Taylor 1970, Raser 1972, Taha 1971). These applications have often resulted in substantial improvement of management efficiency and effectiveness.

Most decision-making problems in fisheries and wildlife management can be approached in a fairly standard manner (Figure 1). The philosophy underlying the approach to problem-solving outlined in Figure 1 is an adaptation of the classical scientific method with an added dimension of time (Lackey 1974). The step involving evaluation of alternative management strategies is particularly amenable to analysis by computer implemented modeling.

Many types of models are used in decision analysis. Monte Carlo simulation is probably the most commonly used type (Lamb 1967), and it may be the most useful technique for fisheries and wildlife managers (Clark and Lackey 1975). We will focus our attention on Monte Carlo simulation in this paper.

A Monte Carlo simulator produces frequency dis-

tributions of many possible outcomes for a simulation problem, rather than providing any single solution. Frequency distributions allow calculation of an expected outcome or mean, as well as a variance. A more extensive discussion of Monte Carlo simulation can be found in texts by Schmidt and Taylor (1970), Raser (1972), or Taha (1971).

Monte Carlo simulation is based on the availability of probabilistic information regarding relevant decision variables. This information should consist of a fairly extensive and complete data set for each variable. The data are usually obtained from past records or through experimental analysis.

One of the problems in modeling fisheries and wildlife systems is that scientific technology is presently unable to measure or quantify many fisheries and wildlife variables. For example, one of the major outputs of recreational fisheries is angler benefits, but no widely accepted measure of these benefits exists. Other variables which can be measured often require unrealistic and unjustifiable effort by biologists and field technicians to obtain each datum.

Another problem is that experimental analysis of fisheries and wildlife variables may be impractical. Fisheries and wildlife managers have economic and political constraints. For example, it would not be feasible to run an extensive experiment to determine the relationship between the cost of a fishing license and the number of licenses sold. The analysis would require different, in fact random, license fees to be levied each year for 5 to 10 years. As a result, the quantitative information necessary for decision models in fisheries and wildlife management is usually incomplete.

Managers must make decisions about complex problems despite the lack of quantitative data. Subjective information may be the best or only available information upon which to base a decision. Even when this occurs, it should benefit managers to use a systematic approach, including use of models, for the particularly complex decision problems.

A technique of probability assignment developed by Lamb (1967) can be utilized to take advantage of subjective information. Decision models can be developed which utilize the full range of knowledge of a particular decision problem.

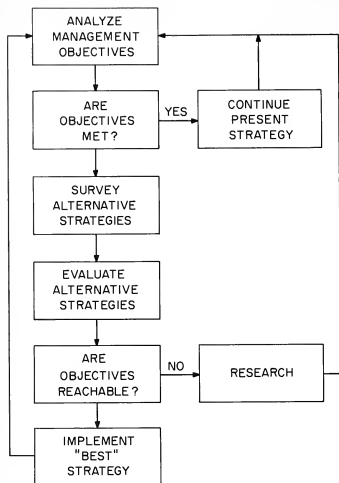


FIG. 1—General fisheries and wildlife management decision-making model based on the scientific method for problem-solving [reproduced from Lackey (1974)].

### The Weibull Function

Lamb used the Weibull probability density function (PDF) because of its desirable analytical properties, and because the user can fit the function to available data, along with his personal judgment about the behavior of a variable. The Weibull PDF is capable of depicting or approximating the full range of unimodal shapes of variable distributions (Figure 2). In addition, it is fairly simple mathematically.

There are some examples of the use of the Weibull PDF in natural resource management. Bailey and Dell (1973) summarize the history and literature of the Weibull PDF and its application in forestry. Lobdell (1972) applied subjective Weibull distributions in MAST, a linear programming model for wildlife agency budget allocation. A Monte Carlo simulator, PISCES, has been developed to aid planning in state fisheries management agencies (Clark and Lackey 1975). PISCES is based entirely upon subjective Weibull probability distributions to describe random variables. A Monte Carlo simulator of walleye population dynamics utilizing Weibull probability distributions was recently developed for use by Texas Parks and Wildlife Department. This model, WALL-EYE, has been used with considerable success for predicting which reservoirs in Texas are suitable for walleye fisheries.

We will summarize Lamb's development of the technique for using the Weibull PDF in Monte Carlo simulators because of the relative inaccessibility of his paper.

Low, most probable (mode), and high estimates of a random variable are the only information required to fit the Weibull PDF. To illustrate the technique let:

- $X$  = random variable;
- $p(X)$  = probability density function for  $X$ ;
- $X_0$  = mode of the PDF;
- $X_1$  = estimate of the lowest value of  $X$  that can occur;

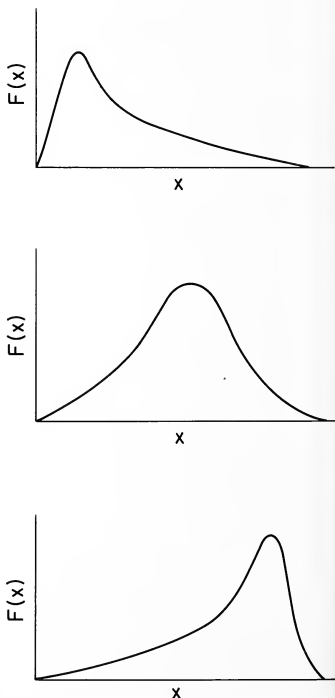


FIG. 2—Three possible (and likely) unimodal shapes for probability distributions encountered in fisheries and wildlife management decision analysis.

$P_1$  = probability that  $X$  is less than  $X_1$ ;

$X_2$  = estimate of the highest value of  $X$  that can occur; and

$P_2$  = probability that  $X$  is greater than  $X_2$ .

If  $P_1$  and  $P_2$  are assigned extremely small values so that their probabilities are essentially zero, then  $X_1$  and  $X_2$  are endpoints of a range of possible values to which the variable  $X$  can be assigned.

The above estimates describe properties of the probability distribution for  $X$  and form the basis for the following constraints:

$$\left. \frac{d[p(X)]}{dX} \right|_{x_0} = 0 \quad (1)$$

$$P_1 = \int_0^{x_1} p(X) dx \approx 0 \quad (2)$$

$$P_2 = \int_{x_2}^{\infty} p(X) dx \approx 0 \quad (3)$$

Theoretically, there are an infinite number of PDF's which would satisfy the above constraints. When the true distribution form is not known, the Weibull distribution can be assumed for convenience and versatility. The three-parameter Weibull PDF can be written in the form:

$$p(x) = \frac{m}{L^m} (X - K)^{m-1} \exp \left[ - \left( \frac{X - K}{L} \right)^m \right] \quad (4)$$

where

$$\begin{aligned} X &\geq K \\ m &\geq 0 \end{aligned}$$

and,

$m$  = shape parameter

$L$  = scale parameter

$K$  = constant

Values for  $m$ ,  $K$ , and  $L$  can be approximated for any unimodal variable by an iterative technique. The family of Weibull distributions which results is nearly symmetrical. The bell-shaped normal distribution is approximated when the shape parameter,  $m$ , is equal to 3.5. For higher values of  $m$ , the distribution assumes a skewed shape "tailing" to the left, and for values less than 3.5, the distribution tails to the right.

Once the three parameters for the Weibull PDF have been determined for a given variable, common methods of random number generation (Schmidt and Taylor 1970) can be used to incorporate the distribution into Monte Carlo simulators.

Lobdell (1972) wrote a computer program, WEIBUL, to generate Weibull distributions for a linear programming model. We revised the program so that it can be used with a process generator (random number generator), for Monte Carlo simulators. WEIBUL, written in FORTRAN IV, calculates the parameters of a Weibull PDF, given low, most probable, and high estimates of a random variable, and then the parameters are used in another subroutine

RANDOM, to generate a random value within the distribution. The program listing and documentation are available from the authors.

### Discussion

Computer-implemented modeling has the potential to benefit fisheries and wildlife management. It has benefited the military and industrial complexes, and their problems are as complex as fisheries and wildlife problems. With today's advances in electronics, computational costs are relatively low. Cost effectiveness of computer use is excellent, and continues to improve. The future trend of computer usage by fisheries and wildlife management should be an upward one.

The technique developed by Lamb (1967) for assigning probability distributions to variables should help fisheries and wildlife managers incorporate their full range of knowledge into decision-making models. This technique is not proposed to substitute for biological research, management research, or data collection, but to be used in conjunction with these activities.

A good rule to follow is to assign distributions to variables based on experimentation and hard data whenever possible. Subjective information should be used when:

- (1) the event concerning the variable has never occurred in the past and experimental analysis is impractical;
- (2) very little or no data exist for the event concerning the variable and experimental analysis is impractical; and/or
- (3) no data for the event concerning the variable can be obtained prior to the time it is necessary to render a terminal decision.

The result should be models which would make the best predictions from the available information.

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Manuscript received August 9, 1976

## Shrews (Insectivora: Soricidae) of the Paddy Knob-Little Back Creek Area of Western Virginia

**Abstract**— We sampled small mammals periodically from 1972 to 1975 in the Paddy Knob-Little Back Creek area of Bath County, Virginia. Among the five species of shrews collected were specimens of the water shrew, *Sorex palustris*, apparently the first that have been captured in Virginia, and the uncommon long-tailed shrew, *S. dispar*. The other species were *Sorex cinereus*, *S. fumeus* and *Blarina brevicauda*.

Bath County is located in the Ridge and Valley Province of the Appalachian Highlands in western Virginia. On the north it borders Highland Co., Virginia, and on the west Greenbrier and Pocahontas Counties, West Virginia. Possibly suggestive of its remoteness, topography, and vegetation, Bath was one of the last counties in Virginia to harbor the mountain lion and timber wolf (Handley and Patton 1947). The area included in this survey is very near Paddy Knob, elev. 1340.5 m, in northwestern Bath County. We collected in a grassy wildlife clearing approximately 0.8 km below Paddy Knob, and along the upper drainage of Little Back Creek beginning approximately 1.6 km south of Paddy Knob.

The wildlife clearing, elev. 1280.5 m, is on a narrow ridge separating the James River (Little Back Creek) and Ohio River (Bird Run) drainages. Most of the 1.6 hectare plot is covered by timothy, *Phleum pratense*, although mats of wild strawberry, *Fragaria virginiana*, are present in much of the field. Spotty shrub and small tree growth includes blackberry, *Rubus* sp., and black locust, *Robinia pseudo-acacia*. Black locust is abundant along the edge of the surrounding deciduous forest. A man-made pond 8 m by 15 m over which we misnetted bats is located at the south end of the clearing.

The upper valley of Little Back Creek was sampled at elevations ranging from about 915 to 1160 m. In a zone of mixed mesophytic forest, much of the sampled area is now beech forest. In decreasing dominance, the five most abundant trees and their respective importance values as determined by the Point-Quarter Method (Cox 1967) are beech, *Fagus grandifolia*, (96.9); yellow birch, *Betula lutea*, (48.6); sugar maple, *Acer saccharum*, (39.7); black oak, *Quercus velutina*, (28.7); and black birch, *B. lenta*, (23.4). In addition to beech and sugar maple saplings, the understory includes striped maple, *A. pennsylvanicum*,

common witch hazel, *Hamamelis virginiana*, and wild hydrangea, *Hydrangea arborescens*. Outcroppings of barren and moss-covered sandstone including several small talus slopes are present on the sides and floor of the valley. Fallen trees in various stages of decomposition are evident throughout the area.

The only long term climatological data available for the area (Schworm 1941) are from Marlinton, Pocahontas County, West Virginia. Marlinton, elev. 649 m, is approximately 49 km west of Paddy Knob. The mean January and July temperatures are -2.0 and 20.0C, respectively, and mean dates without killing frosts extend from 16 May to 3 October. Average precipitation at Marlinton ranges from a low of 7.4 cm in November to about 12.5 cm in July.

We used snap-traps supplemented with live traps and sunken can traps. A mixture of peanut butter and rolled oats was used for bait. Mammals collected were prepared as standard museum skins and skulls or skulls only, or were fluid-preserved whole, and are deposited in the Virginia Commonwealth University Mammal Collection. Cranial measurements were taken as described by Choate (1972), and were recorded to the nearest 0.1 mm, using dial calipers and a binocular microscope.

Table 1 provides the general sites of capture, standard measurements, and selected cranial measurements of the shrews that were collected. Numbers represent total captures except for *B. brevicauda*, of which twenty were collected in the wildlife clearing and 20 along Little Back Creek. On the basis of trapping effort, 500 trap nights in wildlife clearing and 2700 along Little Back Creek, *Blarina* was much more abundant in the wildlife clearing.

Our specimens of *S. palustris* are the first to be recorded for Virginia, although Hooper's (1942) *S. p. punctulatus* was based on specimens collected nearby in West Virginia. All three of our specimens were taken near the water, one in a trap set in the open on top of an emerged rock in the stream.

The rare *S. dispar*, unknown from Virginia until 1955 (Handley 1956) was taken in talus along Little Back Creek. Schwartz (1956) summarized known records of *S. dispar* and regarded West Virginia and Virginia as a region of intergradation between northern and southern taxa, *S. d. dispar* and *S. d. blitchi*. Hall and Kelson (1959) included West Virginia and

TABLE I

Measurements (in mm) of shrews captured in the Paddy Knob area. Measurements of males (M) and females (F) in the samples of *B. brevicauda*, *S. fumeus*, and *S. cinereus* have been combined. WC designates animals captured in the wildlife clearing and LBC animals captured along or near Little Back Creek

Species	Site of capture		Total Length	Tail Length	Condylobasal Length	Maxillary Length	Cranial Breadth	Interorbital Breadth
	WC	LBC						
<i>Blarina brevicauda</i>	X	X	115.0	25.0	22.4	7.8	12.2	5.7
9F, 1M			(110.0-125.0)	(23.0-31.0)	(21.9-22.9)	(7.7-8.1)	(11.3-12.7)	(5.2-5.9)
			10	10	10	10	10	10
<i>Sorex fumeus</i>	X	X	114.0	46.0	18.3	5.2	9.0	3.7
3F, 3M, 7?			(111.0-117.0)	(41.0-47.0)	(18.0-18.8)	(4.6-5.5)	( 8.9-9.2)	(3.5-3.9)
			7	7	7	12	7	12
<i>Sorex cinereus</i>	X	X	94.0	38.0	15.5	4.1	7.6	3.0
8F, 6M, 4?			( 78.0-104.0)	(32.0-41.0)	(15.2-15.8)	(4.0-4.3)	( 7.3-7.9)	(2.9-3.1)
			14	14	14	16	16	15
<i>Sorex dispar</i>								
F		X	117	55	17.8	4.4	—	3.4
F		X	115	53	—	—	—	—
M		X	120	56	17.7	4.3	7.8	3.5
<i>Sorex palustris</i>								
F		X	137	63	20.5	6.0	10.2	4.0
F		X	131	66	20.4	6.2	10.0	3.9
F		X	135	66	21.0	6.2	10.3	4.0

Virginia in the range of *S. d. dispar*. Cranial measurements of our specimens are closer to *S. d. dispar*, and all had tail length (a character that Schwartz 1956, used for allocation of specimens to subspecies) within the range of variation in *S. d. dispar*.

Both the smoky shrew, *S. fumeus*, and the masked shrew, *S. cinereus*, were most common in forested situations, but some were captured in traps set in runways for meadow voles in the wildlife clearing. As with *S. dispar*, in most instances *S. cinereus* and *S. fumeus* were taken in traps set under rocks or rotting logs within 20 m of the stream.

Three species of shrews that have been taken in the western part of Virginia although rarely, were not found in this study. The pygmy shrew, *Microsorex hoyi*, is very rare throughout the southern portion of its range. The southeastern shrew, *S. longirostris*, and the least shrew, *Cryptotis parva*, are uncommon at high elevations in Virginia, and each has more southern affinities than do the species of shrews captured in this study. A few *S. longirostris* and *C. parva* have been taken at relatively high elevations in southwestern Virginia. Odum (1944) reported *S. longirostris* from 1067 m at Mountain Lake, Giles Co., and Hooper and Cady (1941) captured *C. parva* between 884 and 945 m in Smyth Co.

Several other mammals were encountered in our study area. A hairy-tailed mole, *Parascalops breweri*, was caught by hand on a logging road along the upper valley of Little Back Creek. Seven species of bats were misnetted over the pond in the wildlife clearing: *Myotis lucifugus*, *M. keenii*, *Pipistrellus subflavus*, *Eptesicus fuscus*, *Lasiurus borealis*, *L. cinereus*, and *Lasiorycteris noctivagans*. Except for one specimen of each species the bats were released after capture. Chipmunks, *Tamias striatus*, were evident throughout the area. The red-backed vole, *Clethrionomys gapperi*, and deer mouse, *Peromyscus maniculatus*, were the most common rodents along Little

Back Creek. The woodland jumping mouse, *Naupaeocapus insignis*, was collected in both the wildlife clearing and along the creek. Meadow voles, *Microtus pennsylvanicus*, were abundant in the wildlife clearing.

**Acknowledgments**—Numerous individuals, but particularly William H. N. Gutzke, III, C. Frederick Murray and Ward C. Rothery, assisted with field work. We thank Drs. John E. Guilday and Charles O. Handley, Jr., for reviewing the manuscript and providing numerous suggestions. The Virginia Electric and Power Company provided support in the first two years of the study.

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Manuscript received July 20, 1976

Revised manuscript received May 14, 1977

## A Microelectrophoretic Study of Red Blood Cells

### Introduction

It has been pointed out by Riddick (1968) that coagulation or agglutination of red blood cells can be caused by ingestion of salts of multi-charged cations and in particular, aluminum salts. Such coagulation may be relevant to an understanding of some cardiovascular diseases. Coagulation of red blood cells is presumed to occur on reduction of the thickness of the electrical double layer associated with the cell by gegenions (counterions). Although such behavior has been studied quantitatively in non-biological colloidal systems like AgBr (Wiersma et al 1966), SiO<sub>2</sub> (Hunter and Wright 1971), TiO<sub>2</sub> (McGown et al. 1965), and Al<sub>2</sub>O<sub>3</sub> (Hunter and Wright 1971), no conclusive documentation was given by Riddick for the case of red blood cells treated as colloidal particles. In addition, it is known that aluminum does not exist as a simple, unhydrolyzed, trivalent ion in aqueous solution at physiological pH(5).

Various aspects of the red blood cell have been reviewed recently (Surgenor 1974, 1975). The ionization of sialic acid (N-acetylneuraminic acid) on the major red cell glycoprotein is responsible for most of the negative charge at the red cell surface (Eylar et al. 1962). The electrical potential associated with the surface of red blood cells can be deduced in several ways but microelectrophoresis is probably the most precise experimental technique. The electrokinetic behaviour of red blood cells has been reviewed very thoroughly with particular emphasis on microelectrophoresis (Seaman 1975). It is important to note that the electrical potential at the surface of the red blood cell,  $\psi_0$ , is not determined by microelectrophoresis, but rather the zeta potential,  $\zeta$ , is obtained. The zeta potential is the electrical potential at the plane of shear between the cell and the suspending medium as the cell undergoes electrophoresis. The location of this plane of shear is not known precisely but it is generally accepted that  $\zeta < \psi_0$  (Shaw 1970).

Inconclusive results were obtained in our initial studies of the coagulation of red blood cells (Duncan 1974) in which chick embryos were directly injected

with small volumes of salt solutions followed by microscopic examination for agglutination. The present work was undertaken to determine the effect of different salts and the concentration of these salts on the zeta potential of human red blood cells as calculated from mobilities measured by microelectrophoresis.

### Experimental

**Apparatus:** Electrophoretic mobilities of the red blood cells were measured in a microelectrophoresis apparatus. The apparatus contained a modified Mattson cell (Mattson 1933) consisting of a constant bore capillary tube (inside diameter: 2.5 mm) with platinized platinum sheet electrodes fitted into the ends of the cell by ground glass joints. The ultramicroscope illuminated the particles at right angles to the viewing direction. Scattered light from suspended cells in the focal plane of the microscope passed into the microscope objective. The eyepiece of the microscope contained a graticule and by measuring the time required for a bright point of scattered light (a red blood cell) to traverse the known graticule spacing (55  $\mu$ m), the electrophoretic velocity was calculated.

**Materials:** Aldehyde-fixed (Haydon and Seaman 1967) human red blood cells were obtained from Dr. J. W. Goodwin, University of Bristol. 8 ml of the stock suspension were alternately centrifuged and washed three times with physiological saline solution (0.145 M NaCl; 0.01 M NaHCO<sub>3</sub>). Sufficient saline solution was added to the washed erythrocytes to make 100 ml of suspension A. One ml of suspension A was diluted with saline solution to make 100 ml of suspension B. Samples of suspension B were used in the micro-electrophoretic measurements. A SEM photomicrograph of red blood cells (suspension B) is shown in Figure 1. The biconcave discoid shape of normal red blood cells is apparent from the photomicrograph. The irregular shape of a few of the cells in Figure 1 is caused by ATP depletion (Weinstein 1974). The vast majority of the cells examined were of normal shape as seen in Figure 1. Suspension B of the aldehyde-fixed cells used in the electrophoresis studies contained  $8.6 \times 10^6$  cells  $\text{cc}^{-1}$  as determined with a Coulter counter.

20 cc of human blood (group O Rh-positive) were placed in refrigerated (4°C) 5% sodium citrate solution on collection. The suspension was alternately

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centrifuged and washed three times with refrigerated saline-phosphate buffer solution (0.135 M NaCl, 0.020M  $\text{Na}_2\text{HPO}_4$ ). The washed erythrocytes were suspended in saline-phosphate buffer solution at an equivalent concentration to that used for the fixed cells. The microelectrophoresis measurements were made within 48 hrs of sampling.

Solutions were made up by dilution with distilled water of appropriate quantities of  $\text{CaCl}_2$  (BDH Chemicals Ltd.),  $\text{La}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$  (Hopkin Williams Ltd.) and  $\text{Al}(\text{NO}_3)_3 \cdot \text{H}_2\text{O}$  (BDH Chemicals Ltd.) which were used as received.

**Procedure:** The thermostatted cell was filled with saline solution. The microscope was focussed on the front and back faces of the cell. The distances traversed were noted on a vernier scale. The microscope was then advanced to focus on a plane within the cell located at a distance of  $0.293r$  from the inner wall where  $r$  is the radius of the cell. This distance corresponds to the location of the so-called stationary plane where velocity of liquid transported by electro-osmosis is zero and particle motion is due solely to electrophoresis (Mysels 1959).

Suspension B was kept in a thermostatted bath ( $25^\circ\text{C}$ ) prior to the microelectrophoretic measurements. The thermostatted cell ( $25^\circ\text{C}$ ) was washed repeatedly with saline solution which had been stored at  $25^\circ\text{C}$ . About 8 ml of suspension B was added to the cell. The electrodes were inserted and the voltage applied. Only those red blood cells seen as bright spots were chosen for timing. After timing one particle, the polarity was reversed, to reduce the effect of electrode asymmetry and another particle selected for timing. This process was repeated 6 times for a total of 14 particles. The motion of the particle as viewed in the microscope is upwards since the particle is simultaneously undergoing electrophoresis and gravitational settling.

### Results and Discussion

Electrophoretic mobilities ( $u$ ) of red blood cells were calculated as the ratio of  $v$  to  $X$  where  $v$  is the measured velocity in  $\text{cm sec}^{-1}$  and  $X$  is the field

TABLE I  
Calculated mobilities and zeta potentials of red blood cells

Suspending Medium	$u(\mu\text{m sec}^{-1}\text{V}^{-1}\text{cm})$	$\zeta(\text{mV})$
0.145 M NaCl	$-1.18 \pm 0.04$	$-15.7 \pm 0.5$
$2.27 \times 10^{-3}\text{M Ca(II)}$	-1.12	-14.9
$5.40 \times 10^{-3}\text{M}$	-0.99	-13.2
$1.14 \times 10^{-2}\text{M}$	-0.92	$-12.2 \pm 0.2$
$2.37 \times 10^{-2}\text{M}$	-0.62	$-8.2 \pm 0.1$
$2.08 \times 10^{-3}\text{M La(III)}$	-0.95	-12.6
$6.0 \times 10^{-3}\text{M}$	-0.74	-9.8
$2.50 \times 10^{-2}\text{M}$	-0.69	-9.2
$6.21 \times 10^{-2}\text{M}$	-0.60	-8.0
$1.25 \times 10^{-2}\text{M}$	-0.52	$-6.9 \pm 0.2$
$2.52 \times 10^{-2}\text{M}$	-0.42	$-5.6 \pm 0.2$
$2 \times 10^{-3}\text{M Al(III)}$	-0.66	$-8.8 \pm 0.4$
$6 \times 10^{-3}\text{M}$	+1.00	+13.3
$2 \times 10^{-2}\text{M}$	+1.51	+20.1
$6 \times 10^{-2}\text{M}$	+1.60	$+21.3 \pm 0.1$

strength defined as the ratio of the applied voltage to the electrical length of the cell. An applied voltage of 90 V was used in all measurements and the electrical length of the cell of 17.2 cm was determined in a separate experiment. The calculated value of mobility of red blood cells in physiological saline solution at  $25^\circ\text{C}$  is given in Table I. This value is in good agreement with the reported value of  $-1.08 \mu\text{m sec}^{-1}\text{V}^{-1}\text{cm}$  (Seaman 1975). Calculated values of the mobility and zeta potential of fresh red blood cells were  $-1.10 \mu\text{m sec}^{-1}\text{V}^{-1}\text{cm}$  and  $-14.7 \text{ mV}$ , respectively.

Zeta potentials are related to the measured mobility by the equation

$$\zeta = 3600\pi\eta u/\epsilon \quad [1]$$

where  $\eta$  and  $\epsilon$  are the viscosity and dielectric constant of the suspending medium respectively. Equation [1] reduces to

$$(\text{mV}) \quad \zeta = 13.29u \quad [2]$$

for physiological saline solution at  $25^\circ\text{C}$ . Zeta potentials calculated using Equation [2] for red blood cells in saline solution containing known amounts of  $\text{Ca(II)}$ ,  $\text{La(III)}$ , and  $\text{Al(III)}$  are given in Table I. It is important to note that the ionic strength and pH of all solutions was adjusted to the same ionic strength ( $= 0.145$ ) and pH ( $= 7$ ) of physiological saline solution with  $\text{NaCl}_{\text{ss}}$  and  $0.1 \text{ N NaOH}$  respectively.

The effect of the concentration of  $\text{Ca(II)}$ ,  $\text{La(III)}$  and  $\text{Al(III)}$  on the zeta potential of red blood cells was determined and the results are compiled in Table I and are plotted in Figure 2. The ionic strength and pH of all solutions in Table I were constant. The effect of increasing  $\text{Ca(II)}$  concentration in reducing the zeta potential of red blood cells is clearly seen in Figure 2. Calcium is known to exist as the simple unhydrolyzed ion at pH 7 and over the measured concentration range (Sillen and Martell 1964). The effect of increasing  $\text{La(III)}$  concentration in reducing the zeta potential of red blood cells is seen also in Figure 2. The much lower concentration of  $\text{La(III)}$  compared to  $\text{Ca(II)}$  to bring about the equivalent reduction in zeta potential is in agreement with the

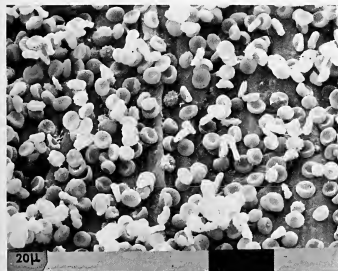


Fig. 1—SEM photomicrograph of red blood cells.

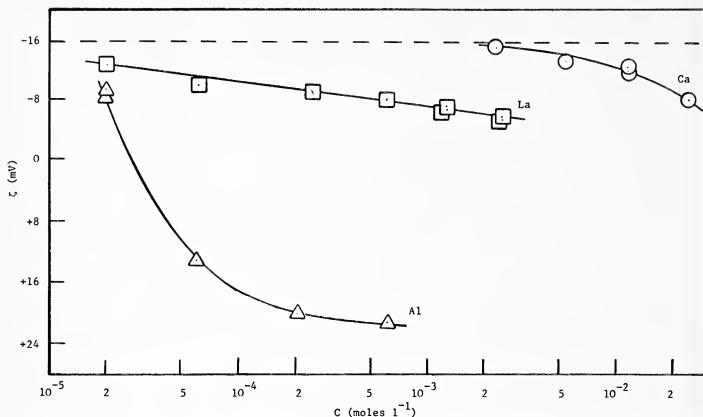


FIG. 2—Effect of concentration of Ca, La and Al on the zeta potential of red blood cells in saline solution at 25°C and at constant ionic strength and constant pH.

Schulze-Hardy rule (Shaw 1970). Lanthanum is one of the few trivalent ions which exist predominantly in the unhydrolyzed state at pH 7 (Sillen and Martell). This was the reason for the use of a lanthanum salt in this work.

The effect of increasing Al concentration on reducing the zeta potential of red blood cells is seen also in Figure 2. At a molar concentration of  $2 \times 10^{-5}$ , Al is more effective than La in reducing the zeta potential of red blood cells ( $-12.4$  vs.  $-8.8$  mV). At higher Al concentrations, charge reversal is noted such that the red blood cells are now positively charged. Aluminum salts in water undergo complex hydrolysis reactions (Matijevic and Stryker 1966, Matijevic et al. 1961, Rubin and Hayden 1973). Aluminum exists primarily as  $Al(OH)_3$  at pH 7 and in the concentration range studied (Rubin and Hayden 1973). However, poly-hydroxy aluminum species also exist in solution (Matijevic and Stryker 1966, Matijevic et al. 1961). It is the interaction of these complex species with the red blood cells which produces the charge reversal noted in the electrophoretic measurements.

The results of the effect of Al on the zeta potential of red blood cells supports Riddick's view (1968) of the potential danger of excessive aluminum salt ingestion. But in fact the present results indicate that aluminum is even more serious than Riddick suggested since Al was treated simply as a trivalent species analogous to La(III). The present results demonstrate conclusively that lanthanum and aluminum both formally trivalent exhibit quite markedly different effects on the zeta potential of red blood cells.

**Acknowledgments**—I thank Dr. J. W. Goodwin for supplying the aldehyde-fixed red blood cells and John Dimery and Pete Rogers in the M. Sc. Laboratory, U. Bristol, for help with this study. The SEM photomicrographs were kindly supplied by Dr. Dudley Thompson, (U. Bristol) and M/S Jane Harfield kindly took the fresh blood samples. The continued interest of Dr. R. D. Dyer in this work is appreciated.

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## Guest Editorial

It has been suggested that an editorial be placed in this, the official organ of the Virginia Academy of Science, not as a codetta crafted by a retiring performer, but rather as a piece written from the vantage point of the outgoing presiding officer. It is intended not so much to reflect upon the past, as to look to the future, that some observations will be made.

The state of the Academy is good. Like most other organizations, the Academy has been subjected to financial pressures with the results that not all areas of potential or even proper concern find sufficient dollar support. In 1968, for example, the total receipts of the Academy were slightly over twenty-nine thousand dollars; for 1976 our projected income is estimated to be about thirty-three thousand dollars—but the value of the dollar has been said to have slipped in this interval, making thirty-three thousand in 1976 the equivalent of twenty thousand dollars in 1968!<sup>1</sup> In spite of these factors, but mainly owing to the dedicated volunteer work of many individuals within the Academy, our organization has broadened its support of science-related activities and is now actually funding programs not formerly embraced. These areas include a loan to the Flora Committee for the publication of an updated atlas and map of Virginia Flora (to be printed and sold at cost), a subsidy by the Science Education Committee for science teacher workshops, funds granted to the Bicentennial Committee for the "one-time" support of a special observation of the Nation's Bicentennial, and funds for the care of the Academy archives. All of the aforementioned represent only eight percent of the Academy's annual budget.

The Academy continues major support of the Virginia Junior Academy of Science (circa 20% of total Academy budget) and subsidy of the *Virginia Journal of Science* (circa 30% of total Academy budget). From 1968 to 1976 support of the Visiting Scientists Program has inched up to six hundred fifty dollars from four hundred dollars (2% vs. 1.5% of the budget), which is barely sufficient to sustain this valuable activity. On the other hand, the Academy's direct support of research via the research grant program has shrunk from eight percent to only six percent of Academy budget. This fact is disturbing to many members of the Academy; however, it is not out of step with similar trends in the governmental and industrial sectors. There are some ways that our organization could increase its support of scientific research; unattractive ones would be to cut back or eliminate funding of the areas of science publication—public relations or science education. It should be observed that the Editor of the *Virginia Journal of Science*, working with the Publications Committee and the printer of this *Journal*, The William Byrd Press, has already effected considerable savings in the printing costs of the *Journal*, with the

result that subsidy of the *Journal* now is less than it was formerly. A more reasonable way to increase Academy funds for research would be to increase the size of the Trust Fund, the income from which currently provides the money for research grants. Recently, the Trust Committee arranged for a slightly higher yielding investment mechanism for the Academy's trust funds; but no one can expect this to result in a great increase in income for research subsidy.

While on the topic of the *Journal*, it would be worth noting that over the past few years some state academies have ceased publication of their journal, or changed format from journal to newsletter. I think that the *Virginia Journal of Science* is a worthy publication, an endeavor of value to the scientific community, and an activity which should not be abandoned by the Virginia Academy of Science. I also think that the *Virginia Journal of Science* must be tailored to a broader base of reader appeal and in this connection have suggested that it incorporate some of the attributes of a newsletter. Information which would be appropriate for inclusion would be a column on member news and section activities. In addition, it seems to me that greater interest in the *Journal* on the part of the Academy Section Editors should offer more input to the *Journal*. It has been observed that Dr. William D. McElroy, President, American Association for the Advancement of Science, feels the publication of pure research papers—particularly in biology—is not the proper pursuit of that organization's journal, *Science*<sup>2</sup>. That cry is not unfamiliar to the ears of the Editor of the *Virginia Journal of Science*, nor to the ears of other Academy officers. To my way of thinking, a middle ground philosophy should be pursued for our *Journal*, but encouragement should be extended to authors to submit manuscripts of original papers, especially those from the educational, technological, and non-biological areas (but not to exclude biological or graduate student papers).

How has our membership fared, or rather, what is the status of numbers of members in the Virginia Academy of Science? About 1970, the number of members reached an all-time peak of slightly more than seventeen hundred (1,400 regular members plus 280 contributing, sustaining, student or life members plus 34 business members of the Academy). In 1975, the total membership dropped to fifteen hundred, the principal loss being about 200 regular members, or an attrition of 13%. More disturbing, however, was the loss of 10 business members between 1968 and 1974. With the efforts of the Business Relations Committee, chaired by President Powell, this trend has been reversed and there are now 25 business members of the Academy.

The trend of disenchantment or disfranchisement of the industrial-technical peoples has been ably remarked upon by Dr. McElroy: "A wedge was driven between the industry and the university after World

<sup>1</sup> Data, U.S. Bureau of Labor Statistics: The Consumer Commodity index indicates that \$100 in May of 1968 is the equivalent buying power of \$164 in May, 1976, or  $\$33,000 \div 164 \times 100 = \$20,000$ . For the Academy's 1976 budget to have the same buying power as the \$29,000 of 1968, the 1976 income would have to approach \$47,560.

<sup>2</sup> Ref. "Changes Due in Science Association" New York Times Service, December, 1975. (Interview with Dr. McElroy).

War II when science gained new non-industrial financial support. This was an unfortunate separation. There must be a free flow of ideas and knowledge between the universities and the industrial community if we expect to solve our major problems in energy, population control, food production, land use, water use and the like."<sup>2</sup>

I would like to point out that the Virginia Academy of Science is now addressing itself to some of these problem areas within our Commonwealth. The Science Advisory Committee has been cooperating with our State Government on matters of the environment, for example, by serving on the Water Quality Standards Advisory Committee, State Water Control Board. In addition, the Academy has sponsored lectures on energy problems ("Science and the World of Tomorrow", Dr. Thomas O. Paine, Senior Vice President, G.E. Corp.; "New Energy Sources for the 1980's", Dr. Aaron Wold, Prof. of Chemistry and Engineering, Brown University), food problems (Dr. William J. Darby, President, The Nutrition Foundation, New York), and has provided a forum for symposia on science and technology topics that have impact on our environment (Joint Session, 1975 annual meeting—Engineering and Environmental Sciences Section: "Impact of Federal Water Pollution Control Act Amendments of 1972 on the State and Nation") and, that deal with science education (Symposium on Science Museums). Undoubtedly, the tireless efforts of a handful of Academy members, mostly serving on the Science Museum Committee, have brought nearer to reality a State Science Museum and a science museum network for our Commonwealth.

Our Membership Committee has been working to recruit new members to the Academy, especially from the community and junior colleges and the university

campuses. These labors are beginning to bear fruit. A reservoir which has hardly been tapped is the many hundreds of science teachers from the public and private secondary schools of Virginia. I am firmly convinced that aside from an occasional "joiner", the Virginia Academy of Science can only attract as members those persons who can foresee some professional benefit to themselves from such an affiliation. The Long Range Planning Committee is currently compiling a documentation of such benefits from Academy membership. Ultimate financial restraints notwithstanding, it is the endeavors of the members of the Academy—their devotion and selfless service—that makes our organization move ahead. I would submit, therefore, that educators, "science-users" and academicians should join our Academy AND participate in the programs of the Academy. Then they may ask, "what will membership do for me?"

With the permission of one of our newly elected Honorary Life Members, I will close this collection of variations on a theme by excerpting a recent letter from him:

"Looking back over the past half century, I can only conclude that the Academy has been a far greater factor in shaping my career than any influence I have had on its growth and value to the people of Virginia and to science in general. It is I who is indebted to the Academy; not the reverse. The Virginia Academy of Science has indeed been a potent factor in my life and I am sure that the stimulus to learn more and more in the field of science has enabled me to pass on to my students much that they would have missed had I not been a member of the Academy."

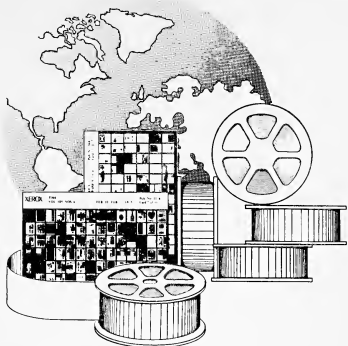
Arthur W. Burke, Jr.

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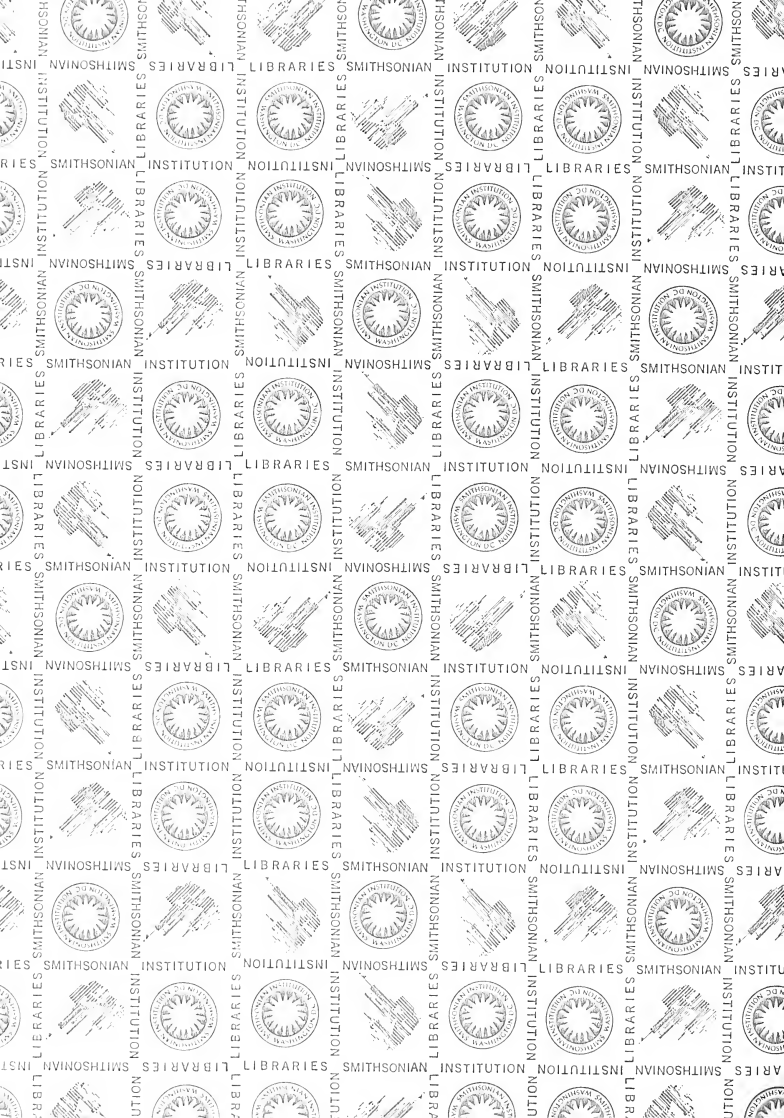














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